ISSN 0377-9335

ENTOMON

Vol. 20 March 1995 No. 1

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ASSOCIATION FOR ADVANCEMENT OF ENTOMOLOGY
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ENTOMON

Entomon is a quarterly journal of the Association for Advancement of Entomology issued in March, June, September and December, devoted to publication of research work on various aspects of insects and other arthropods.

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Two Decades as Managing Editor of ENTOMON...

Prof. V. K. K. Prabhu who has been steering ENTOMON since its inception in the year 1975 relinquished this position as its Managing Editor in January 1995. It is gratifying to note that by now the Journal has to its credit a coveted distinction among world scientific journals primarily absorbing adequate nourishment and hormonal elicitation from V. K. K. metamorphosing into a fullfledged adult. Even though the journal was started as biannual, later in 1979 it was made a quarterly. The meticulous and superb services rendered by V. K. K. in molding and mending this journal to its present form can never be forgotten. The regularity and continuity maintained in the publication of each of its issues, liberal publication policy adopted not at the risk of sacrificing the quality of papers are perhaps some of the yardsticks which the Managing Editor adhered to with regard to ENTOMON as it should be the case with any of the good international journal. In that way ENTOMON was indeed fortunate to get such services from Prof. V. K. K. during its formative period. Now it is at a stage when ENTOMON has already earned such an international status as an excellent journal of insect science, its entire credit can be mostly attributed to none other than Prof. V. K. K. Prabhu. In this context, when ENTOMON is growing from its name to fame, Prof. Prabhu's name shall always be synonymous to ENTOMON.

D. Muraleedharan

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Sex Pheromone Gland and Calling Behaviour of Female Spiny Bollworm *Earias insulana* (Biosduval)

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Received on March 31, 1993

Abstract: Histological studies were made to identify the sex pheromone gland of female *Earias insulana* which was found situate din the intersegmental region between 8th and 9th abdominal tergites and tergites, sternites and pleurites of the 9+10 segment. The pheromone release behaviour of the female was studied by making visual observations under a 14L: 10D photoperiod. Females assumed a characteristic posture during the terminal hours of scotophase exposing the glandular tissue. Olfactometer bioassays showed such females to be attractive to males indicating pheromone release. The pheromone release-'calling'-behaviour is described.

Key words: spiny bollworm, *Earias insulana*, pheromone release, calling, bioassay, sex pheromone gland.

INTRODUCTION

The spiny bollworm *Earias insulana* is a major pest of cotton and okra in the African continent, the Indian subcontinent and the Mediterranean region. During investigations on identification of the sex pheromone, Hall *et al.*, (1980) found the females of this species to yield very negligible amount of pheromone (<1 ng). It is possible that they extracted the pheromone from the females at a time when the female sex pheromone glands did not contain sufficient pheromone, as it has been reported in case of Lepidoptera, that females of some species contain extractable amount of pheromone is their glands only during certain periods under certain conditions (e. g. Webster and Carde, 1982; Raina *et al.*, 1986). A need was therefore felt to identify the sex pheromone gland and to determine whether females took a posture resembling calling during only a specific period and whether females taking such a posture were attractive to males, thereby indicating the release of sex pheromone.

MATERIALS AND METHODS

The methods of insect rearing, pheromone bioassay, and the 'T' olfactometer used were similar to Tamhankar *et al.*, (1989). The experiments were conducted under a 14L: 10 D photoperiodic cycle. The histological method used to identify the sex pheromone gland was similar to one described earlier (Tamhankar *et al.*, 1993). For behavioural observations, immediately after emergence virgin females were individually caged in plastic container (6.5 cm dia 6 cm height) along with sucrose solution and okra fruit. Visual observations on whether females took any characteristic posture resembling calling were recorded at 15 min intervals during the dark phase, as the insect is reproductively active only during this period. Such observations were recorded during the first five days of adult life.

Five batches of 3 females each, which took a characteristic posture, were bioassayed in the 'T' olfactometer, using 3-5 males/assay for 5 min, to ascertain whether such females indeed

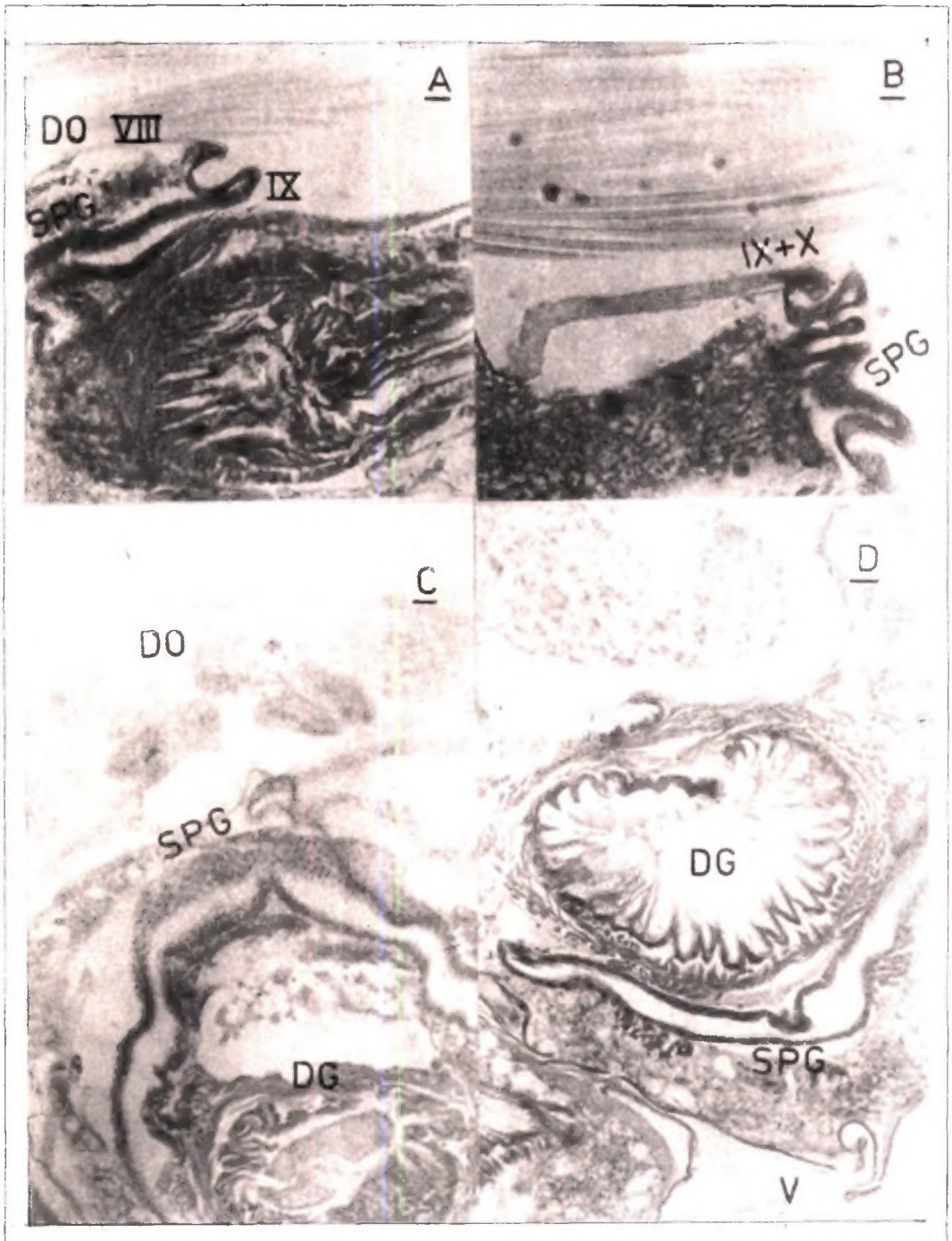

Fig.1 Microphotographs of sex pheromone gland of female *Earias insulana*. A. glandular epithelium in the intersegmental region between 8th and 9th abdominal segment, (longitudinal section). B. Lateral continuity of glandular epithelium in 9+10 segment (longitudinal section). C. glandular epithelium on the dorsal side of the 8_9 abdominal segment (transverse section). D. same as C but ventral side. (DO=dorsal side; VIII, IX, X = segmental numbers; SPG = sex pheromone gland cells; V = ventral side; DG=digestive tract). (Note: transverse sections are slightly angular).

released a sex pheromone attractive to males. Three females were taken at a time because handling during bioassay caused some disturbance due to which at times one or two females were likely to stop calling for a while. The response of males to calling females was calculated as per Tamhankar *et al.*, (1989).

Results and Discussion

Observations of a large number of sections of the abdominal segments showed that the intersegmental membrane between the 8th and 9th abdominal segment on dorsal side and almost the entire 9+10 abdominal segment on the dorsal and ventral side possessed epidermal cells considerably enlarged than were found in case of other segments (Fig. 1 A, C, D). Lateral continuity of these cells in the 9th and 10th abdominal segment was also indicated (Fig. 1B). These cells were similar in appearance to the ones found in sex pheromone glands of other Lepidoptera i. e. cuboidal to columnar in shape with large nuclei and a cuticle varying in thickness. The sex pheromone gland of *E. insulana* female was found similar in all respects to that of female *E. vittella* (Tamhankar *et al.*, 1993). In Lepidoptera in general and in many species of family Noctuidae, only the intersegmental region between the 8th and 9th abdominal segment is modified into a glandular epithelium either dorsally or ventrally. However, in some subfamilies of family Noctuidae, a variation similar to *E. insulana* has been noticed. For example, in Heliothinae, the gland consists of a ventrolateral chevron in the intersegmental membrane between abdominal segments 8 and 9+10 besides a second glandular area in the dorsal valves (Aubrey *et al.*, 1983; Teal *et al.*, 1983). In Amphypyriinae, in *Sesamia nonagriodes* L. the gland is located in the ventral area around ostium bursae and in a ring shaped area around ovipositor, almost as if the two intersegmental membranes are modified (Sreng and Sreng, 1988).

In a resting female the abdominal segments, 8th onwards with the sex pheromone gland, remained telescoped inside the body. Fig.2 shows a virgin *E. insulana* female in a characteristic calling posture. It can be seen that during calling the female profruded the terminal abdominal segments outside her body directing them ventrally, thus exposing the sex pheromone gland. In this posture the glandular tissue in the intersegmental fold between the 8th and 9th segment bulged out and the gland in the entire 9+10 segment formed a ring like structure, it's tergites, sternites and pleurites all being modified into a glandular tissue. It was also observed that during calling the terminal segments were slowly extended and retracted at regular intervals, perhaps giving a pulsed signal.

Fig.2 Calling female *Earias insulana*

The calling posture of the *E. insulana* female differed from the congeneric *E. vittella* female in the angle at which the wings were held over the body during calling. The wings of *E. vittella* females made an angle of about 45° to the substrate (Tamhankar *et al.*, 1993), but the wings of *E. insulana* made a negligible 5°-10° angle.

When bioassayed with males in olfactometer, *E. insulana* females with the characteristic' calling' posture attracted 52.6% of the males in 5 minutes, indicating the occurrence of pheromone release (Table 1). As is typical with the 'T' olfactometer, the male response increased from 21% in the first minute to 52.6% in the 5th minute as the following occurred, a) with the passage of time the released pheromone reached the farthest section of the olfactometer

along with the gentle airflow and b) males with delayed pheromone response latencies or with higher threshold concentration requirement started showing attraction. It was evident from the bioassay results that the females were releasing the pheromone continuously during the assay period.

Minutes	% male attraction (mean of 5 assays)
1	21.0
2	22.2
3	38.8
4	47.3
5	52.6

Visual observations revealed that out of the females observed (n=30), none called on the day of emergence and it was only by day 5 that all the females had started calling. Perhaps, gland competency (Tang *et al.*, 1991) was absent on the day of emergence and only by day 5 gland competency developed in all the females. The earliest a female initiated calling on a day was during the 8th hour of scoto-phase, with peak calling activity being noticed during the last hour of scoto-phase. Observations on calling behaviour of 5 day old females revealed that 80 percent females had only 1 or 2 bouts of calling, the mean being 1.8 and the range being 1-4 bouts. The bout length varied from 15 to 150 minutes and the mean duration of calling for 5 day old females was 61.6 min. The calling behaviour of female *E. insulana*, generally resembled that of female *E. vittella* (Tamhankar *et al.*, 1993). Having identified the sex pheromone gland and the calling posture, effect of various endogenous and exogenous factors on the calling behaviour of female *E. insulana* is being presently studied.

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An Energy Budget for the Angoumois Grain Moth, *Sitotroga cerealella* (Olivier).

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Received on April 12, 1992

Abstract: An energy budget was developed, for the first time, for all life stages of the Angoumois grain moth Sitotroga Cerealella (Olivier) reared singly on whole paddy grains. Estimated consumption of rice grains, respiration, insect biomass and rejecta were determined. Mean energy in calories (cal) accumulate din biomass per individual in the developmental stages was estimated. During larval development, *S. cerealella* removed only 64 per cent (47.04 cal) of the grain energy from a grain containing 73.50 cal. Of the total consumption, 15.47 cal was voided as rejecta and 31.57 cal was assimilated. Out of the assimilated energy, 6.17 cal was converted to larval biomass and 25.40 cal was required for respiration. Pupa and adult contained 4.05 and 5.14 cal respectively.

Key words: Rice, Angoumois grain moth, energy budget.

INTRODUCTION

A rational strategy of stored grain management is to minimise the flow rate of energy from grains to higher trophic levels (IMURA & Sinha, 1986). During storage, the energy accumulated in energy rich grains flows out through various channels of food chains in stored-grain ecosystems (SINHA, 1973) and in consequence, loss from stored grains inevitably occurs. Energy budget has been constructed for several stored product insects, viz., *Rhyzopertha dominica* (F.) (Campbell & Sinha, 1978), *Cynaeus angustus* (Le Conte) (White & Sinha, 1981), *Oryzaephilus surinamensis* (L.) (Whe & Sinha, 1981), *Cryptolestes ferrugineus* (Stephens) (Campbell & Sinha, 1978), *Sitophilus granarius* (L.) (Campbell *et al.*, 1976), *Sitophilus oryzae* (Singh *et al.*, 1976), *Ephestia cautella* (Walker) (Sinha *et al.*, 1986), *Plodia interpunctella* (Hubner) (Imura & Sinha, 1988). An excellent review covering earlier bioenergetic data on various insects, including stored product pests is also available (Wiegert & Peterson, 1983). But, to our knowledge, no assessment of energy loss through an energy budget has been developed to date for the Angoumois grain moth. *Sitotroga cerealella* (Olivier) (Gelechiidae: Lepidoptera), a serious pest of stored paddy in our country.

MATERIALS AND METHODS

Five groups, each with 300 paddy grains were placed into 500 ml beakers separately. Grains from each group were weighed individually and numbered with pencil. Ten pairs of freshly emerged adult moths were exposed to the grains in the beaker and covered with filter paper. Simultaneously 100 grains with known individual weight were maintained as control. To ascertain moulting to higher instar, a minimum of five infested grains from each group was dissected every day and head capsule width of the larva inside the grain was measured, for determining the larval instars (Crombie, 1943). On the day of moulting to the next instar, twenty grains were dissected from each group and the freshly moulted larvae and unfed remains of the grains were weighed and dried.

All biological materials were dried at 60°C upto 48 h. The control and infested grain other than specimens for calorific determination, were dried at 103°C for 72 h in an air oven (Anonymous, 1976). The weighings were done in an electronic balance with sensitivity of 1µg. Insect bodies, their by-products and grains were powdered separately and formed into pellets. When the biological material in a sample was smaller than 5 mg, benzoic acid was added as

a carrier, so that the combustion of the pellet would yield sufficient energy to heat the bomb (Paine, 1971). Energy content was determined using a Parr 1411 semi-micro bomb calorimeter as per the methods in the Standard Manual for Bomb Calorimetry No.128 and 130.

The energy budget for *S. cerealella* was constructed adopting the equation of Pewtrusewicz and Macfayden (Petrusewicz & Macfadyen, 1970).

Food consumption, rejecta and production were estimated in terms of dry weight separately for each instar. Food consumption (C) was estimated by subtracting the dry weight of grain remains on the day of moulting to the next instar from the dry weight of the grain at the commencement of the instar. Rejecta (Fu) includes faeces, exuviae and silk. The weight of faeces was estimated by collecting from each grain separately. On the day of moulting to next instar, subtracting the dry weight of faeces for the earlier instar from the total dry weight of the faeces on the day of moulting to the next instar, faeces for each instar was estimated.

Production (P) was calculated by subtracting the dry weight of the larva at the commencement of the instar from that at the end of each instar. Respiration (R) and Assimilation (A) was calculated by Gravimetric method i.e., R=A-P and A=C-Fu (Wightman, 1981).

Rates of Consumption (Cr), Assimilation (Ar), Production (Pr) Respiration (Rr) and the ecological efficiencies were calculated as under:

$$Cr = \frac{C \text{ (cal insect}^{-1})}{\text{Mid body wt. (g)} \times \text{Instar duration (day)}}$$

$$Ar = \frac{A \text{ (cal insect}^{-1})}{\text{Mid body wt. (g)} \times \text{Instar duration (day)}}$$

$$Pr = \frac{P \text{ (cal insect}^{-1})}{\text{Mid body wt. (g)} \times \text{Instar duration (day)}}$$

$$Ae = \frac{A}{C} \times 100$$

$$Pe1 = \frac{P}{C} \times 100$$

$$Pe2 = \frac{P}{A} \times 100$$

$$\text{Mid body wt.} = \frac{\text{Final body wt.} - \text{initial body wt.}}{2}$$

Cr-Consumption rate; Ar-Assimilation rate; Pr-Production rate; Rr-Respiration rate; Ae-Assimilation efficiency; Pe1-Gross production efficiency; Pe2-Nett production efficiency.

Results and Discussion

The mean dry weight of insect biomass, rejecta and rice grain is shown in Table 1. Mean egg biomass was 0.004 mg. Mean larval biomass was low (0.035 mg) for first instar and high (1.45 mg) for fourth. The mean biomass of pupae and adult was 0.97 and 0.98mg, respectively. Rejecta was least (0.001 mg) when the insect was in first instar stage and largest (3.079 mg) in fourth instar.

Amount of food consumed by individual insect in individual grain was found to be 13.095 mg which was 64 per cent of the total weight of the grain (Table 1). The energy content of the larva ranged from 2.42 cal per mg (first instar) to 4.88 cal per mg (fourth instar). The energy content of egg, egg shell, pupa, pupal case and adult was found to be 2.00, 12.23, 4.17, 3.19 and 5.25 cal per mg respectively. Rejecta and rice grain had a mean energy content of 5.02 and 3.59 cal per mg respectively (Table 1).

Rate of consumption was high (4704. 85 cal/g live weight /day) during fourth instar and low (3193.38 cal/g live weight/day) during first instar stage (Table 2). Rate of respiration was more in first instar larval stage (2735.28 cal/g live weight/day) than in other instars. Energy loss through respiration was maximum (14.01 cal) during fourth instar and minimum (0.49 cal) during first instar (Fig.1). The cumulative energy loss through respiration during larval development was found to be 25.40 cal (Fig.1).

An energy budget for *S. cerealella* feeding on rice grain is presented schematically in Figure 1. During larval development, it removed only 64 per cent (47.04 cal) of the grain energy from a grain containing 73.50 cal. Of the total energy consumed, 15.47 cal was Estimated as rejecta and 31.57 cal was assimilated. Out of latter, 6.17 cal was converted into larval biomass and 25.40 was used for respiration. Pupae and adult contained 4.05 and 5.14 cal respectively.

Assimilation efficiency for first, second, third and fourth instars was found to be 99.1, 62.3, 74.2 and 62.8 per cent respectively. Net production efficiency for the above instars was 13.6, 54.7, 16.3 and 17.7 per cent respectively.

Table 1. Biomass and energy values of the various life stages and by-product of S.cerealella and food consumed

Life stages or by-product	Biomass (mg x 10^{-3})			Cumulative food consumed (mg x 10^{-3})			Energy values of insect (cal/mg)		
	n	Mean	SE	n	Mean	SE	n	Mean	SE
Egg	5[a]	4	3				5[a]	2.00	0.036
Larva									
L_1	5[a]	35	8	20	160	8	5[a]	2.42	0.072
L_2	5[a]	390	19	20	1091	27	5[a]	3.21	0.088
L_3	5[a]	840	27	20	5552	108	5[a]	4.29	0.054
L_4	5[a]	1460	68	20	13096	186	5[a]	4.88	0.024
Pupa	20	970	25				5[a]	4.17	0.060
Adult	20	980	103				5[a]	5.25	0.079
Egg case	5[a]	2	2				5[a]	1.23	0. 043
Pupalcase	20	120	29				5[a]	3.19	0.054
Rejecta									
L_1	5[a]	1	11				5[a]	5.02	0.013
L_2	5[a]	252	18						
L_3	5[a]	1075	24						
L_4	5[a]	3079	89						
Whole rice grain	20	20460	383				5[a]	3.59	0.001

a. Group of 20 individuals

Gross production efficiency for them was found to be 13.5, 34.1, 12.1 and 11.2 per cent respectively. The cumulative assimilation. net production and gross production efficiency during larval development was found to be 67.1, 19.6 and 13.1 per cent respectively.

Table 2. Rate of comsumption, assimilation, production and respiration by *S. cerealella* reared on rice grain (Calories/g live weight/day)

Stages	Consumption rate	Assimilation rate	Production rate	Respiration rate
L_1	3193.38	3165.49	430.21	2735.28
L_2	3215.77	2003.27	1096.44	906.84
L_3	3468.64	2573.71	418.36	2155.40
L_4	4704.85	2956.96	524.81	2432.12

Energy consumed by larvae of different stored product pests is relatively proportional to the species biomass, *E. cautella* (Sinha *et al.*, 1986), *P. interpunctella* (Imura & Sinha, 1986), *C. angustus* (White & Sinha, 1987), and *S. granarius* (Campbell *et al.*, 1976) have the highest consumption values followed by *S. cerealella*. *O. surinamensis* (White & Sinha, 1981) and *C. ferrugineus* (Campbell & Sinha, 1978) have the lowest consumption.

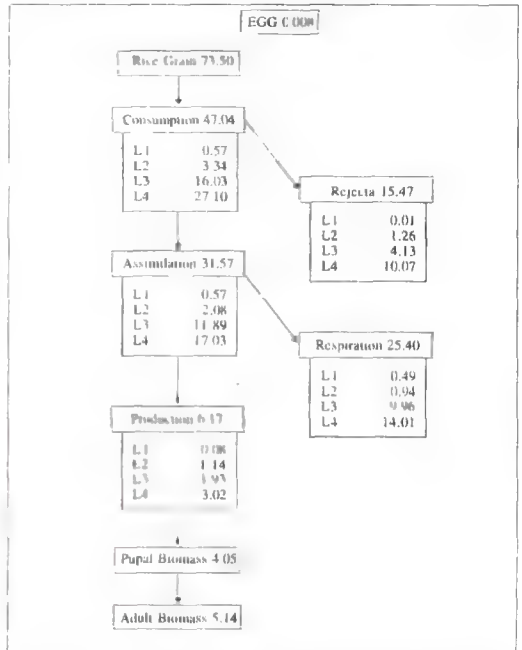

Fig. 1. Energy flow diagram showing energy utilization in calories, by various stages of *S. cerealella* on rice grain

The mean energy content of eggs was little

lower than that of another lepidopteran pest *E. cautella* (Sinha *et al.*, 1986). Of all developmental stages, first instar larvae of *S. cerealella* had the lowest energy value and thereafter the values increased progressively, as the larvae developed to fourth instar. This increase was probably related to an increase in lipid content during development (Hiratsuka, 1917) and has been reported for *S. granarius* (Campbell *et al.*, 1976) and *P. interpunctella* (Imura & Sinha, 1986).

The average energy value for all larval stages of *S. cerealella* was lower than the average for all larval stages of *P. interpunctella* fed on corn (Imura & Sinha, 1986) and *E. cautella* fed on wheat (Sinha *et al.*, 1986). The energy value of the pupae was lower than that of fourth instar larvae but increased to 5.25 cal/mg in adult. The energy content of rejecta was more compared to those of other stored product insects. The main reason for the high energy content of rejecta was that in the present study, it includes faeces, exuviae and silk. The energy value of a rice grain was 3.59 cal/mg.

The mean oxygen consumption per individual increased progressively during larval development. The respiration was more during first instar larvae because of the high larval mobility during this stage. Total energy lost by respiration was more in *E. cautella* (Sinha *et al.*, 1986) and *P. interpunctella* (Imura & Sinha, 1986) than *S. cerealella*. This is because of the fact that immature stages of *S. cerealella* are internal feeders and their movement is restricted.

The cumulative assimilation efficiency for *S. cerealella* was 67.1 per cent. Lepidopteran larvae generally use 25-40 per cent of consumed food (Chapman, 1972) although this varies from 21.6 to 60.1 per cent for various species (Wiegert & Peterson, 1983). The cumulative gross production efficiency of *S. cerealella* was 13.1 per cent which was more or less similar to the value for *P. interpunctella* (Imura & Sinha, 1986) and *E. cautella* (Sinha *et al.*, 1986). The cumulative net production efficiency of *S. cerealella* was lower than that of *P. interpunctella* and *E. cautella*. Since the larval growth was low compared to the amount of energy assimilated, the net production efficiency was lower than that of *E. cautella* and *P. interpunctella*.

A knowledge of energy flow and food use in *S. cerealella* under optimal conditions is important to our understanding of the pest activities and the resulting potential losses to stored products and will help in formulation of future control strategies based on the metabolic activity of the insect.

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ENTOMON 1995 VOL. 20 NO. 1 PP. 11 TO 14

Effect of Buprofezin, an Novel Insect Growth Regulator, Against Cotton Whitefly *Bemisia tabaci* Genn.

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Received on July 29, 1992

Abstract: The effectiveness of moult inhibitor, buprofezin against nymphs of cotton whitefly *Bemisia tabaci* Genn. was studied. The early stage nymphs were highly susceptible to buprofezin. The cumulative percentage mortality of nymphs varied from 48.5 to 99.1 (first instar) and 43.7 to 98.9 (second instar) with increase of concentration from 0.1 to 25 ppm. In the case of third and fourth insatars, maximum mortality of 99.1% and 98% was obtained at higher concentrations of 150 and 1000 ppm respectively. Buprofezin treated nymphs exhibited various types of morphological deformities at three to four days after their exposure

Key words: *Bemisia tabaci*, buprofezin, percentage mortality, nymphal instars, feeding rate, morphological deformities.

Introduction

The whitefly *Bemisia tabaci* Genn. has become a serious pest of cotton in India. The elimination of natural enemy complex of the pest and rapid selection for insecticide resistance due to excessive and indiscriminate use of broad spectrum insecticides are reported to be the principal factors responsible for the massive out break of *B. tabaci* (Ahmed *et al.*, 1987, Ajri *et al.*, 1986). To overcome this crisis the broad spectrum insecticides should be used to the bare minimum. Other alternate, timely and target specific methods relatively safer to natural enemies are necessary for the effective management of *B. tabaci*.

The insect growth regulator, buprofezin (2-tert-butylimino-3-isopropyl-5-phenyl 3-4, 5-6-tetrahydro-2-H-1, 3,5-thiadiazin-4-one) a recently synthesized moult inhibitor has been reported to be highly specific and effective against Homopteran pests such as *Trialeurodes vaporariorum* (Westwood) and *B. tabaci* (Yasui *et al.*, 1987, Ishaaya *et al.*, 1988), *Nilaparvata lugens* Stal., *Sogatella furcifera* Horv., *Nephotettix virescens* and *Laodelphax striatellus* Fallen (Kanno *et al.*, 1981, Thang *et al.*, 1987). However, no comprehensive work has been carried out on the bioefficacy of buprofezin against cotton whitefly in India. The present study was to evaluate the bioefficacy of buprofezin against cotton whitefly *B. tabaci*.

Materials and Methods

Chemicals: Various Concentrations of buprofezin (Applaud®) 25 WP (from Nihon Nohyaku Co. Ltd., Japan) was used in the study.

Test insect: *B. tabaci* nymphs were reared on cotton seedlings in the glass house. The average temperature and humidity condition was 28± 2°C and 65±10% respectively. Cotton seedlings (45 days old) raised in plastic cups (10 x 7 cm) were trimmed retaining only the top two

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This forms part of Ph. D. thesis by the senior author in part fulfillment of the requirements for the Degree to TNAU, Coimbatore, Tamil Nadu, India, 1989.

Table 1. Effect of buprofezin on first, second and third instar *B. tabaci*

Concn (ppm)	Mortality (%)		Conc (ppm)	Mortality (%)
	First instar	Second instar		Third instar
0.10	48.5 ± 0.9 d	437 ± 0.2 c	5	34.4 ± 0.2 f
1.25	51.4 ± 0.7 d	50.3 ± 0.3 c	10	60.2 ± 0.2 e
2.50	89.2 ± 2.3 c	79.3 ± 0.5 b	25	81.3 ± 0.3 d
5.00	95.8 ± 1.7 b	97.5 ± 0.7 a	50	90.3 ± 0.2 c
10.00	98.9 ± 0.2 a	98.9 ± 0.1 a	100	95.7 ± 0.9 d
25.00	99.1 ± 0.1 a	98.8 ± 0.1 a	150	99.1 ± 0.2 a
Control	4.4 ± 0.4 e	5.3 ± 0.8 d	Control	6.4 ± 1.5 g

Data are means ± SE of three replicates of 25-50 nymphs each.
Within columns figures followed by the same letter do not differ significantly (p=0.05; DMRT)

leaves. The under surface of the leaves were cleaned by using a camel hair brush in order to remove eggs or nymphs of whitefly if any. *B. tabaci* adults were confined at the rate of 20 pairs per seedling using mylar cages for 24 hours. The oviposited plants were examined under a stereoscope in order to get required larval instars. In a preliminary observation, the moulting and duration of each instar was studied and based on this the first, second, third and fourth instar nymphs were selected for testing on the same day of moulting that corresponded on day 7, 10, 13 and 16 of oviposition respectively (Plate I). Nymphs which were not in the respective stages were removed before the treatment.

Table 2. Effect of buprofezin on early and late fourth instar *B. tabaci*

Conc (ppm)	Mortality (%)	
	Early IV instar	Late IV instar
100	53.0 ± 0.4 d	48.4 ± 0.2 e
200	64.4 ± 0.7 c	55.8 ± 0.6 d
300	92.6 ± 0.3 d	60.7 ± 0.4 c
500	94.8 ± 0.3 d	66.6 ± 0.5 b
1000	97.9 ± 0.7 a	76.8 ± 0.5 a
Control	0.01 e	0.01 f

Data are means ± SE of three replicates of 25-50 nymphs each.
Within columns figures followed by the same letter do not differ significantly (p=0.05; DMRT)

Biological assays: The effect of buprofezin on nymphal instars *B. tabaci* was evaluated by leaf dip method after Laska (1986) with minor modifications. Initial count of nymphs was recorded and the leaves with the nymphs were dipped at various concentrations of buprofezin for 20 seconds. Each treatment was replicated thrice and the treated seedlings were covered individually with mylar cages (30 x 10 cm). The nymphal mortality and other morphological changes were recorded from third day onwards. In a preliminary trial the time taken for the manifestation of toxic symptom was observed as 4 days. The cumulative mortality was recorded on day 6 of treatment (DT) on attaining maximum nymphal mortality and continued and observation till the normal adult emergence in control and presented as cumulative percentage mortality. Treatments were compared with Duncan's (1955) multiple range test (DMRT) after transforming the percentage values into angular values.

Results and Discussion

Buprofezin had a strong nymphicidal effect on early instars of *B. tabaci*. The cumulative per cent mortality of nymphs varied from 48.5 to 99.1 (first instar) and 43.7 to 98.8 (second instar) with increase of concentration from 0.1 to 25 ppm. (Table 1.). Mortality of 89% was attained with first instar nymphs even at a low concentration of 2.5 pm. With the second instar nymphs 97% mortality was caused at 5 ppm.

The effectiveness was decreased as the age of larvae advanced. A maximum mortality of 99.1% was recorded at 150 ppm (third instar) while in the case of fourth instar it was 97.9% at 1000 ppm. (Table 2.) Buprofezin treated nymphs have manifested various types of morphological derangements. At higher concentrations the treated nymphs have failed to moult. At lower doses they have attempted moulting but were incapable of casting the exuviae and died in a typical moulting position with dried exuviae attached to their bodies. The newly deposited cuticle was transparent and less rigid. The abnormalities observed with fourth instar nymphs were partial adult formation, partial adult emergence, emergence of malformed adults and non-survival adults. Buprofezin was found to be 50-100 times more effective than conventional insecticides on homopteran insects (Asai *et al.*, 1983, Shibuya, 1984). A dose dependent variation in effectiveness was reported on *N. lugens* (Izawa *et al.*, 1985).

Buprofezin showed almost the same level of toxicity on the first and second instar of *T. vaporariorum* and was effective on all stages except late fourth instar (Yasui *et al.*, 1985). The present observations are in conformity with the above results. However, the difference in effective concentration of buprofezin against *B. tabaci* from that of other insects is expected since the susceptibility spectrum of different species are basically different. Delayed larval mortality and abnormal moulting was reported on buprofezin treated *N. lugens* (Asai *et al.*, 1983), *N. virescens* (Heinrichs *et al.*, 1984) and *T. vaporariorum* (Yasui *et al.*, 1985). The exact mechanism responsible for the mortality of the larvae had been identified as the strong inhibition of chitin synthesis and thereby deposition of a less rigid cuticle that leads to the manifestation of various morphological abnormalities (Uchida *et al.*, 1985). The delayed symptom might be due to the fact that these compounds are acting only at the time of moulting.

Since the conventional insecticides and the synthetic pyrethroids are proved ineffective for whitefly management this new insect growth regulator can very well fit into a long term and stable whitefly management system because of the desirable attributes like long persistent toxicity and relative safety to natural enemies along with high larvicidal action.

ACKNOWLEDGEMENT

We thank Nihon Nohyaku Co. Ltd., Tokyo, Japan for supplying buprofezin used in the present study. The senior author expresses her gratitude to Dr. S. Jayaraj (Director, Centre for Plant Protection Studies, presently, Vice-Chancellor, Tamil Nadu Agricultural University, Coimbatore) for providing the facilities for the study and the Indian Council of Agricultural Research for the financial assistance.

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Effect of Multiple Mating on Fecundity and Fertility in the Tropical Tasar Silkworm, *Antheraea mylitta* d. (Lepidoptera: Saturniidae)

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Received on January 30, 1993

Abstract: The females mated twice lay more eggs than females mated once. Observations indicate that more sperm and fecundity enhancing substances are transferred during copulation which enhances the rate of fecundity and fertility in the females mated more than once

Key Words: *Antheraea mylitta*, Multiple mating, Fecundity, Fertility.

INTRODUCTION

In several insects oviposition is stimulated by male derived factors transferred along with sperm during copulation. This influences the physiology and behaviour of the female and enhances the reproductive success in terms of fertility and fecundity (Engelmann, 1970). The reproductive consequences of several important aspects of mating system and nature of impetus to egg laying provided by mating seem to differ considerably among insects (Lawrence, 1990) *Antheraea mylitta* is a semi domesticated, polyphagous lepidopteran insect and it has great commercial value as it produces Tasar silk. Low fecundity and fertility are the major reasons for low multiplication rate. In *A. mylitta*, the mating duration in the wild condition is more than ten hours. However, a period of 4 to 8 hr. is found to be optimum for getting high fecundity and fertility (Annual report of CTR & TI, Ranchi, 1973-74). Although a female moth contains 250-300 eggs, the egg laying capacity is of 150-200 and a sizeable number of eggs are retained inside the body. This retention of eggs causes considerable loss to the Tasar industry. No systematic approach appears to have been undertaken to solve this problem. The present experiment is an attempt to study the effect of multiple mating on egg laying and egg retention in the body of female Tasar silkworms.

MATERIALS AND METHODS

Healthy Daba bivoltine race of *A. mylitta* moths of either sex were used for the present study. In one group newly emerged female moths were hand coupled with fresh males for four, six and eight hrs duration, while in another group, fresh female moths were initially coupled with fresh males for two, three and four hour and after decoupling, the females were mated with other males for the same duration. The body weight of male and female moths in both the groups were 2 gm and 8 gm respectively. After decoupling, the female moths were placed in wet earthen cups for egg laying. Though the egg laying continues for 6-7 days, only first 3 days layings were collected and kept in plastic egg hatching boxes. The whole experiment was replicated twice (each replication contained 15 female moths). The experiment was conducted at natural day length of approximately 12 hr. The temperature and humidity recorded were 25.8±2.4°C and 70-80% respectively. Statistical analysis was done by one way ANOVA (Bailey, 1966).

Table 1. Comparative performance of single and multiple mating on egg production, retention and hatching in *A. mylitta*

Treatment	Duration (hr.)	No. of eggs Mean±SE)	Percentage of eggs (Mean ± SE)	Percentage of hatching (Mean ± SE)
Single mating	4	207.26±3.72	26.89±0.85	72.55±2.29
	6	228.67±4.56	23.15±0.73	69.37±1.64
	8	215.23±3.15	26.14±0.79	72.08±1.57
Multiple mating	2 + 2	271.80±3.92	9.46±0.63	94.39±0.57
	3 + 3	292.61±3.62	4.09±0.31	98.20±0.29
	4 + 4	282.40±4.12	6.42±0.56	95.64±0.62
	C.D 5%	12.76	1.11	1.51
	C.D 5% (pooled)	15.07	1.81	3.89

C.D. - Critical Difference, N.S - Not Significant

Result and Discussion

Female mated once have lower fecundity and fertility than females mated twice and laid lower proportion of eggs than females allowed to remate (Table 1). Then female receptivity was not reduced while remating. Remated females laid 250-300 eggs whereas, single mating resulted in lower fecundity (less than 250 eggs). The hatching percentage of the eggs was substantially increased in remated moths. Moreover, the egg retention was reduced and life time fecundity was increased.

A possible reason for the lower fecundity and hatching percentage in single mated female could be the depletion of sperm and fecundity enhancing substances (FES) in the female reproductive tract (Gillot and Friedel, 1977). In *A. mylitta* it may be possible that even though the males are robust, the sperm and FES from a single individual are not sufficient to fertilize and release all the eggs from a female thereby necessitate remating. Thus multiple mating ensures the availability of sperm and other FES. Accessory gland and seminal vesicle of an unmated male shows thick whitish appearance in comparison to mated ones where the depletion of the gland contents are obvious. It appears that the secretion of the male accessory glands play an important role in enhancing fecundity as mated females lay more eggs than virgins (authors' unpublished observations).

Repeated matings have shown in the increase of fecundity, fertility and longevity in a number of insects, viz. *Drosophila melanogaster* (Pyle and Gromko, 1978); *D. pseudoobscura* (Pruzan-Hotchkiss *et al.*, 1981) *Gryllodes sigillatus* (Subramanian, 1989); *Tetraopes tetra opthalmus* (Lawrence, 1990); *Panolis flammea* (Leather, 1990); *Nezara viridula* (Maclain *et al.*, 1990); *Epiphyas postvittana* (Danthanaryana and Gu, 1991); and *Mystacides azurae* (Petersson, 1991). In *Bombyx mori* mating duration upto 6 hr. reduced the preoviposition period and increased the total egg output and hatching (Thomas Punitham *et al.*, 1987). It is reported that queens in many hymenoptera mate with several males to produce several patrilinies of daughters which in turn enhances the survival rate through intra-colony genetic variability (Gadgkar, 1992).

There are selective advantages for females which mate repeatedly such as (1) increasing oviposition under condition where insufficient nutritional resources (Spermatophores and FES) were limiting factors in reproduction and (2) to increase intracolony genetic variability which

provides resistance to diseases that might otherwise spread rapidly among the population.

ACKNOWLEDGEMENT

The authors are thankful to Mr. A. K. Goel and Mr B. N. Brahmachari of Central Tasar Research & Training Institute for the statistical analysis.

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ENTOMON 1995 VOL. 20 NO. 1 PP. 19 TO 21

Longevity and Fecundity of *Dinarmus basalis* (Rondani) (Hymenoptera: Pteromalidae) A Useful Parasitoid of *Callosobruchus chinensis* (L.) (Coleoptera: Bruchidae)

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Received on July 15, 1993

Abstract: The pteromalid parasitoid, *Dinarmus basalis* (Rondani) oviposited on different larval, pre-pupal and pupal stages of *Callosobruchus chinensis* (L.) and fed on the body fluids through the feeding tubes made by the ovipositor. Developmental stages of the host affected longevity and fecundity of the parasitoid significantly ($P<0.01$). Both longevity and fecundity were highest on 4th instar host larvae but lowest on 2nd instar. This was primarily because of intrinsic differences of food of different instars/stages of the hosts supplied

INTRODUCTION

Dinarmus basalis (Rondani) is one of the dominant pteromalid parasitoids of *Callosobruchus chinensis* (L.), a serious pest of various stored pulses. It lays egg on the body surface of the mature larvae, pre-pupae and pupae which live within the seeds of the lentil, *Lens esculentus* (L.) (Southgate, 1979, Islam *et al.*, 1985; Islam, 1991).

Age of the host may have a profound effect on oviposition and development of parasitoids (Vinson & Iwantsch, 1980) because the nutritional status and accessibility of the hosts may change with age. No research on the effect of host age on longevity and fecundity of *D. basalis* is available. An investigation was, therefore, undertaken to determine the effects, if any, of host age on the longevity and fecundity of female *D. basalis*.

MATERIALS AND METHODS

A large number of mated females of *C. chinensis* were introduced in different Petri dishes (11.5 cm diam) containing fresh red lentil, *L. esculentus* covered with transparent lid and placed in the incubator at 30±1°C for oviposition. After two hrs., *C. chinensis* were removed from the Petri dishes.

When the seeds were 8-,10-, 12-, 14- and 16-day old they were removed from the incubator randomly. Eight-day old seeds were kept in the Petri dishes containing water, for 5-7 hours. When the outer cuticle of the seeds was soft, the seeds were dissected to trace out the presence of *C. chinensis* larvae. Subsequently, the 10-, 12-, 14- and 16-day old seeds were sorted out and dissected in the same way of the *C. chinensis* respectively.

Unmated females of *D. basalis* (below 24 hours of age) were confined with males and fed on honey for 24 hours to increase their egg-production. Each female was supplied with 50 hosts of each stage in different Petri dishes (8.5 cm diam) for 24 hours. The Petri dishes were covered with transparent lids and were placed in an incubator at 30± 1°C. The Petri dishes were removed from the incubator every day for introduction of fresh seeds in place of parasitized ones. Parasitized egg-containing seeds of different ages were kept individually. The ovipositing females were held by the aspirator and again introduced in different Petri dishes after introduction of freshly-infested seeds of different ages. Seeds with eggs of different ages were dissected and the total number of eggs laid by each female was then counted. Such procedures were continued until all the females of each stage were dead. The longevity of the

females was noted when the ovipositing females were dead. Parasitized seeds with 2nd and 3rd instar larvae were kept in Petri dishes containing water for 5 hours daily until the outer cuticle of the seeds was soft. The seeds were then dissected to observe the parasitoid eggs. The eggs were collected from other stages of the parasitized seeds directly with fine forceps. Data were obtained for at least five females with host of each stage. The experiments were replicated four times.

Results and Discussion

The female parasitoid penetrates its sharp and pointed ovipositor through the surface of the seed-cost and places an egg on the external surface of the host. After oviposition the female withdraws the ovipositor from the seed and again inserts it to form a feeding tube extending from the surface of the body of the host to outside the seed and feeds on the host fluid that oozes out through the feeding tube, It is believed that this food significantly increases the number of mature eggs in the ovaries (Edwards, 1954; DeBach, 1979).

The mean longevity of *D. basalis* parasitizing 2nd, 3rd and 4th instar larvae, pre-pupae and pupae of *C. chinensis* is shown in Table 1. Results show that the longevity of female *D. basalis* varied significantly on various stages of *C. chinensis* ($P<0.01$). The highest and lowest longevity of the parasitoid were recorded on 4th and 2nd instar *C. chinensis* larvae respectively. The mean oviposition of *D. basalis* on various stages of *C. chinensis* is shown in Table 2. Host-stage significantly affect the fecundity of the parasitoid ($P<0.01$). Again, fourth instar larvae produced the highest number of eggs in *D. basalis*.

Table 1. Mean longevity of female *D. basalis* parasitizing host of different stages

Host instar/stages	Ne	Range (days)	Mean±SE
2nd instar	20	8-15	10.40 ± 0.40e
3rd instar	20	11-23	16.65 ± 0.72d
4th instar	20	22-40	31.90 ± 1.23a
Pre-pupa	20	23-32	27.20 ± 0.59b
Pupa	20	15-26	20.90 ± 0.71c

*Figures followed by the same letters were not significant at $p<0.05$ by the DMRT

Table 2. Fecundity of *D. basalis* parasitizing in different stages of host

Host instar/stages	Ne	Range (No/eggs)	Mean±SE*
2nd instar	20	34-58	43.70±0.22d
3rd instar	20	124-266	189.05±7.86c
4th instar	20	365-601	494.05±14.33a
Pre-pupa	20	393-559	467.75±11.08a
Pupa	20	256-400	335.40±10.06b

*Figures followed by the same letters were not significant by the DMRT

The results indicate that the development stages of the *C. chinensis* influence both longevity and fecundity in female *D. basalis* that parasitizes on it. The 4th instar larvae were the most suitable (and preferred) than the other stages. Potential fecundity of females parasitizing hosts at this stage of development was the greatest not only because of a higher initial rate of egg maturation but also because of a longer oviposition period, resulting from a greater longevity. Though actual counts were not made of the number of eggs laid during a female's life time, it is estimated that a maximum of over 600 eggs per female would be laid if the 4th instar larvae were available throughout the life.

The ovipositing females of *D. basalis* deposited more eggs on the later stages of the host than on the earlier ones. Though the parasitoids take more time for drilling of the infested seeds on the early stages of development (Dhir, 1977), in the present work, where hosts of different stages were simultaneously exposed, the ovipositing females chose the infested seeds which contained 4th instar larvae or later stages.

Differences in oviposition rate presumably resulted only from differences in the rate at which eggs matured in the ovaries. As all the ovipositing females were of uniform size and were reared under identical conditions, the only factor likely to modify this parameter was the food obtained by the females from different stages of the host. Theoretically, this food could differ either quantitatively or qualitatively. As the fluidity of the different stages of the host varies, it seemed probable that the food pro-

vided by the 2nd and 3rd instar larvae was less adequate than that supplied by 4th instar larvae, pre-pupae. Alternatively, less time was needed for oviposition by *D. basalis* on 4th instar larvae, pre-pupae and pupae than 2nd and 3rd instar larvae. In the absence of any strong evidence for quantitative differences in food intake, it seems more likely that qualitative changes in the food provided by different stages of the host were involved.

A situation analogous to that studied in the present investigation involves differences in food provided by hosts of different species. Various investigations (Leius, 1963; Wylie, 1963; Narendran & Joseph, 1976 and Hegazi *et al.*, 1977) showed that such food differences profoundly affected parasite longevity and fecundity.

The effects on adult parasites of food obtained from different stages of *C. chinensis* were in many respects similar to the effects recorded earlier by Leius (1961a, b); Wylie (1962); and Timerak (1983) in other hymenopterous parasites that feed on host tissues or fluids. *D. basalis* females parasitizing various stages of *C. chinensis* and without other food live up to about 5 weeks at 30±1°C. In addition, the mean daily oviposition increased when females parasitized and fed on different stages of *C. chinensis* for several days. In view of these findings it is concluded that for mass rearing of *D. basalis* for biological control programmes it would be desirable and advantageous to use the 4th instar host larvae of *C. chinensis*.

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ENTOMON 1995 VOL. 20 NO. 1 PP. 23-26

Comparative Development, Progeny Production and Sex Ratio of the Exotic Parasitoid *Leptomastix dactylopii* Howard (Hym., Encyrtidae) on *Planococcus lilacinus* and *P. citri* (Homop., Pseudococcidae)

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Received on October 30, 1992

Abstract: The solitary encyrtid Brazilian parasitoid, *Leptomastix dactylopii* How., was able to complete its development in three nymphal stages and adult females of the mealybugs, *Planococcus lilacinus* (Ckll.) and *P. citri* (Risso). Parasitoid development was faster, the number of parasitoids emerging was greater and the ratio of female to male was higher in the later stages of the host. *L. dactylopii* could be easily cultured on 15-25 day old *P. lilacinus*. *P. lilacinus* in the absence of *P. citri* could be recommended for the mass breeding of *L. dactylopii* since the number of parasitoids emerged and per cent female progeny obtained with *P. lilacinus* and *P. citri* as hosts were very similar

Key words: *Leptomastix dactylopii*, *Planococcus lilaciunus*, *P. citri*, development, progeny production, sex ratio, host suitability.

INTRODUCTION

The Brazilian encyrtid parasitoid, *Leptomastix dactylopii* How. has been utilized in the suppression of the mealybug *Planococcus citri* (Risso) in USA (Fisher, 1963), Island of Procida and Italy (Luppino, 1979), Cyprus (Krambias and Kontzonis, 1980) and India (Krishnamoorthy, 1990). Zinna (1959) first provided an very detailed account of developmental biology of *L. dactylopii*. This parasitoid is believed to be specific to *P. citri* in the field and was multiplied mainly on *P. citri* for field releases (Fisher, 1963; Krishnamoorthy and Singh, 1987). However, attempts were made to maintain *L. dactylopii* on other mealybug species like *Phenacoccus solani* Ferris (Lloyd, 1964) and *Pseudoxoccus comstocki* (Kuw.) (Clancy, 1944). In our laboratory, the parasitoid was found attacking yet another mealybug, *Planococcus lilacinus* (Ckll.). As an alternative to *P. citri*, *P. lilacinus* was tried as a factitious host for the multiplication of *L. dactylopii* and information on comparative development, the number of progeny emerged and sex ratio of *L. dactylopii* on different stages of *P. lilacinus* as well as *P. citri* and their relative suitability for the breeding of *L. dactylopii* is presented in this contribution.

MATERIALS AND METHODS

Both mealybug species, *P. citri* and *P. lilacinus* were maintained in separate rooms on ripe pumpkins (*Cucurbita moschata* Duchesne) as suggested by Chacko *et al.*, (1978). For the studies, gravid, crawler-producing females of *P. lilacinus* were kept for 24 hours on the pumpkin fruits for infestation.

In the first experiment, first and second stage nymphs (sexes morphologically indistinguishable) of 5 and 10 days old respectively, the third female nymphal stage (15 days old), young adult female (20 days old) and gravid

Table 1. Effect of mealybug stage on developmental time, progeny production and sex ratio of *L. dactylopii* on *P. lilacinus* and *P. citri* (Figures in parenthesis are log transformed values)

Stage of the mealybug	Developmenal time (days) on		No. of adults emerged from		Sex ratio (Male:Female)	
	P. lilacinus	*P. citri*	*P. lilacinus*	*P. citri*	*P. lilacinus*	*P. citri*
I instar (5 days old)	23.70 c	..	94.50 a (1.97)	..	1:0.18 a	
II instar (10 days old)	17.84 b	17.15 c	336.42 c (2.52)	340.16 a (2.60)	1:0.59 b	1:0.23 a
III instar (15 days old)	17.27 b	15.00 b	325.64 b (2.51)	354.25 a (2.63)	1:1.50 c	1:0.66 b
Adult female (20 days old)	16.09 a	14.67 b	324.01 b (2.51)	330.26 a (2.53)	1:2.77 d	1:1.34 c
Gravid female (25 days old)	15.75 a	14.21 a	307.85 b (2.49)	302.47 a (2.45)	1:2.89 d	1:1.32 c

Means within the columns followed by the same letter are not significantly different (p=0.05) by least square difference

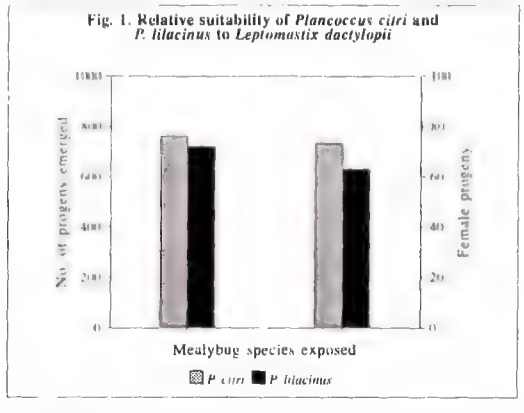
females (25 days old) were tested for their susceptibility to the parasitoid. About 500 mealybugs were maintained on each ripe pumpkin in a cloth-walled wooden cage (30 x 30 x 30 cm). Thirty mated *L. dactylopii* females were released in each cage from oviposition for 24 hours. Each cage with a mealybug infested pumpkin was considered as a replication, and each stage was replicated five times. Parasitoid emergence was recorded daily and their sex ratio was determined. Developmental time was calculated from the day of exposure to the date of emergence.

The second experiment was conducted in order to determine the relative suitability of *P. lilacinus* and *P. citri*. Twenty day old female mealybugs colonized on ripe pumpkins (1000 mealybugs/fruit) was exposed to 50 mates females of *L. dactylopii* in wooden cages for 24 hours. Exposure to each mealybug species was replicated 15 times. Number of parasite progeny emerged from each mealybug species was recorded and later the percentage of females was determined.

All the experiments were conducted at 26±1.5°C and 60-75% RH in the laboratory. The 'F' test was used to compare the differences. For statistical analysis, log transformation was adopted for the number of adults emerged and angular transformation was followed for the percentage of female progeny.

Results and Discussion

Parasitoid Development: *L. dactylopii* was capable of completing its development in the nymphal stages and the adult female mealybugs. The age of the mealybug affected the



parasitoid's developmental time significantly (Table 1). The duration of the parasitoid's development decreased with increase in the age of the mealybug. The mean total development for *L. dactylopii* was significantly longest in hosts that were parasitized in the first nymphal stage. Differences in parasitoid development

time were not significant between second and third nymphal stages of *P. lilacinus* and *P. citri*. Prolonged development of the parasitoid is due to delay in development in early instars of the mealybug, as reported earlier for the encrytids *Anagyrus kamali* Moursi (Moursi, 1948) and *Anagyrus indicus* Shafee *et al.*, (Nechols and Kikuchi, 1985). The shortest development of *L. dactylopii* was observed in gravid female mealybugs. Similar results were reported for *Anagyrus dactylopii* (How.) (Mani and Thontadarya, 1989) and *A. indicus* (Nechols and Kikuchi, 1985; Mani and Thontadarya, 1989).

Sex ratio: The overall sex ratio of *L. dactylopii* that emerged from different stages of *P. lilacinus* varied significantly. Hosts parasitized in the first two nymphal stages yielded more male parasitoid progenies, whereas third nymphal stage and adult female mealybugs produced predominantly more female parasitoid progenies. These differences might be due to possible host size preference for laying male or female eggs, as indicated by Chandler *et al.*, (1980) for *A. pseudococci*. Similar results have been documented by Avidov *et al.*, (1967), Nechols and Kikuchi (1985) and Riherd (1980).

Based on the above results, it is concluded that young females of *P. lilacinus* and *P. lilacinus* (20 days old) were most suitable for the breeding of *L. dactylopii*. However, the parasitoid can be maintained on 15-25 days old mealybugs in the laboratory.

Relatively suitability of *P. citri* and *P. lilacinus* to *L. dactylopii*: The results on the number of parasitoid progeny produced and per cent female progeny obtained from *P. citri* and *P.lilacinus* are summarized in Figure 1. Among the two mealybug species, *P. citri* yielded more adult parasitoids as well as more female progeny. Zinna (1959) also concluded that *P. citri* yielded significantly higher number of parasitoids than other mealybug species. However, the present results obtained with *P. lilacinus* were also very close to those with *P. citri*. Moreover, *L. dactylopii* was bred in large numbers on *P. lilacinus* in the laboratory for two years uninterruptedly without any problem. Hence it is concluded that in the absence of *P. citri*, *P. lilacinus* could be used as a laboratory host for the mass culturing of *L. dactylopii*.

Acknowledgement

The author is grateful to the Director of Indian Institute of Horticultural Research, for providing facilities to conduct the study. He is also thankful to Mr. G. Pattar, Technical Officer, for his assistance in carrying out the experiments

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Suitable Transformation for the Population Count of Coconut Black Headed Caterpillar *Opisina arenosella* Walker (Lepidoptera: Xylorictidae)[1]

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Abstract: For stabilizing the variance of *Opisina arenosella* population counts, seven transformations viz., $\sqrt{x+1}$, log (x+1), log x+k), log (x+k/2), log [log (x+2)], $\sin^{-1}\sqrt{\frac{\beta-1}{\alpha+1}x}$ were tested. The transformation $\sin^{-1}\sqrt{\frac{\beta-1}{\alpha+1}x}$ was found to be effective.

Key words: *Opisina arenosella*, population counts, transformation

INTRODUCTION

The distribution of an insect population should be normalized wherein variance is made independent of mean, before subjecting any data of the population to analysis of variance. Hence, the original data have to be transformed, i. e. the actual numbers are replaced by a function whose distribution is such that it normalizes the data or stabilizes the variance. To find an appropriate transformation for counts of the Black Headed Caterpillar *Opisina arenosella* Wlk., (=*Nephantis serinopa* Meyr.,) a serious pest of Coconut, this study was conducted.

MATERIALS AND METHODS

The population of *O. arenosella* was recorded in a Coconut grove at Nagenahalli, Bangalore under natural conditions from 20 year old trees. Eighty leaflets at random were collected from 20 tree covering the entire canopy. Population in each leaflet was recorded. For 20 sets of data various transformations, viz., log (x = 1), log (x+k), (Kleczkowaskii, 1949), log [log (x+2)] (Tandon, 1985), $\sin^{-1}\sqrt{\frac{\beta-1}{\alpha+1}x}$ (Iwao and Kuno, 1971), $X^{1-b/2}$ (Taylor, 1961), log (x+k/2) (Anscombe, 1948) and $\sqrt{x+1}$ (Bliss & Fischer,, 1953) were applied. The means and variances for the transformed data and for the original counts were computed. The correlation coefficient (r) between mean and variance was used to test the independence of variance and mean (Morris, 1959).

RESULTS AND DISCUSSION

Table 1 presents the mean, variance and the correlation coefficient "r" for 20 sets of data in original and transformed forms. The original count and the transformation ns $\sqrt{x+1}$, log (x+1) and log [log(x+2)], when subjected to correlation analysis, showed significant positive correlation coefficients and the values of correlation coefficient (r) were 0.92, 0.85, 0.68 and 0.51, respectively. High dependence of variance on mean was revealed by increase in mean density with increase in variance. Significant coefficients were obtained for the transformations log(x_k), log(x+k/2) and $x^{1-b/2}$ and values

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Table 1. Suitability of different transformations for stabilizing *O. arenosella* population variance

No.	Original Count (x)		$\sqrt{x+1}$		log (x+1)		Log (x+k)		log (x+k/2)		log[log(x+2)]		$Sin\ h^{-1}\sqrt{\frac{\beta-1}{\alpha-1}}x$		$x^{1-b/2}$	
	mean	variance	mean	variance	mean	variance	mean	variance	mean	variance	mean	variance	mean	variance	mean	variance
1	4.74	21.60	2.20	0.88	1.39	0.82	1.50	0.66	1.24	1.08	0.42	0.23	1.22	0.49	0.96	0.26
2	2.77	12.92	1.75	0.69	0.92	0.80	0.77	1.00	0.42	1.64	0.16	0.24	0.84	0.57	0.70	0.35
3	3.87	19.68	2.03	0.76	1.25	0.66	1.22	0.69	0.99	1.04	0.36	0.18	1.17	0.37	0.99	0.19
4	2.86	9.45	1.82	0.53	1.05	0.63	1.15	0.52	0.84	0.91	0.25	0.19	0.99	0.44	0.85	0.27
5	3.20	11.89	1.91	0.56	1.15	0.59	1.22	0.52	0.94	0.87	0.31	0.17	1.09	0.39	0.92	0.23
6	4.49	17.90	2.18	0.74	1.40	0.67	1.55	0.50	1.31	0.81	0.43	0.18	1.26	0.37	1.03	0.18
7	4.24	22.18	2.08	0.90	1.26	0.84	1.26	0.84	1.00	1.32	0.35	0.23	1.32	0.51	0.92	0.27
8	2.17	3.40	1.70	0.27	0.97	0.40	1.74	0.09	1.30	0.21	0.22	0.13	0.98	0.31	0.88	0.21
9	2.22	5.55	1.71	0.31	0.97	0.39	1.17	0.27	0.84	0.50	0.23	0.12	0.99	0.29	0.90	0.19
10	3.76	7.48	2.11	0.32	1.42	0.28	1.97	0.10	1.64	0.18	0.47	0.07	1.34	0.11	1.14	0.03
11	1.32	1.68	1.47	0.17	0.69	0.32	1.81	0.04	1.27	0.11	0.06	0.12	0.74	0.32	0.71	0.27
12	2.21	3.54	1.72	0.24	1.00	0.33	1.72	0.09	1.30	0.19	0.25	0.10	1.04	0.23	0.95	0.15
13	2.34	2.71	1.77	0.21	1.07	0.29	2.83	0.01	2.26	0.03	0.29	0.09	1.09	0.20	0.99	0.13
14	1.65	2.80	1.55	0.23	0.79	0.37	1.31	0.14	0.88	0.31	0.12	0.13	0.84	0.32	0.79	0.24
15	2.03	5.26	1.65	0.30	0.91	0.38	1.03	0.31	0.71	0.56	0.19	0.12	0.95	0.29	0.88	0.20
16	1.16	1.70	1.41	0.16	0.62	0.29	1.24	0.10	0.76	0.23	0.02	0.11	0.69	0.29	0.69	0.26
17	0.47	0.50	1.18	0.07	0.30	0.17	2.12	0.01	1.47	0.02	0.17	0.07	0.36	0.23	0.38	0.25
18	0.66	0.75	1.25	0.09	0.40	0.20	1.69	0.02	1.09	0.06	0.11	0.08	0.48	0.26	0.50	0.27
19	0.97	1.02	1.36	0.17	0.56	0.24	2.84	0.00	2.20	0.01	0.01	0.09	0.64	0.27	0.65	0.26
20	1.24	1.51	1.44	0.15	0.67	0.28	1.92	0.03	1.37	0.08	0.05	0.10	0.74	0.28	0.73	0.24
r	0.916*		0.850*		0.684*		-0.671*		-0.596*		0.512*		0.187NS*		-0.647*	
t value	9.7109		6.8571		3.9795		-3.8360		-3.1475		2.5264		0.8093		-3.6022	

*- Significant at 5%. NS - Non significant

of correlation coefficients were -0.67, -0.60 and -0.65, respectively. However, the transformation $\sin^{h-1}\sqrt{\frac{\beta-1}{\alpha+1}x}$ had a non significant correlation coefficient (r=0.19). Therefore it is found suitable for stabilizing variance in case of *O. arenosella* population. This transformation makes the variance independent of mean.

O. arenosella population follows an aggregated and negative binomial distribution (Pushpalatha, 1991). For negative binomial distribution, the transformation log(x+k/2) and log (x+k) were suggested by Anscombe (1948) and Kleczkowaski (1949), respectively but both transformations were not suitable for *O. arenosella* population. Anderson (1965) showed that if k is in the region of 2, log(x+k/2) transformation is not appropriate. Hayman and Lowe (1961) compared four transformations and found the transformation log(x+1) to stabilize variance of cabbage aphid *(Brevicoryne brassicae)* counts. For biological populations, Taylor (1965) recommended the transformation $f(x) = x^{1-b/2}$.

Tandon & Veeresh (1987) tested various transformations for stabilizing variance of *Coccus viridis* population counts which followed negative binomial distribution. They found only log[log(x+2)] transformation to be effective in stabilizing variance. Transformations, $\sin^{h-1}\sqrt{\frac{\beta-1}{\alpha+1}x}$ log(x+1), log(x+k), $x^{1-b/2}$ and log[log)x+k/2)] were found unsuitable. Verghese and Tandon (1988) applied various transformations for Mango hopper *(Idioscopus niveosparasus)* and thrips (*Thripspalmi*) population counts to normalize the data and observed the logarithmic transformation, especially log(x+1), to be suitable. Both the species followed a contagious distribution. But none of the above transformations were suitable for *O. arenosella* counts.

However, the transformation $\sin^{h-1}\sqrt{\frac{\beta-1}{\alpha+1}x}$ found suitable for *O. arenosella* population count was reported to be suitable for *Thrips palmi* count on mango by Verghese *et al.,* (1988).

In order to apply this transformation, Iwao's α and ß need to be worked out. Though cumbersome, for meaningful inferences from field data of *O. arenosella*, entomologists have to resort to this transformation.

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ENTOMON 1995 VOL. 20 NO. 1 PP. 31 TO 34

Natural Enemies of *Siphoninus phillyreae* (Homoptera: Aleurodidae) and *Aphis punicae* (Homoptera: Aphididae) on Pomegranate

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Received on March 31, 1993

Abstract: The ash whitefly, *Siphoninus phillyreae* (Haliday) and the pomegranate aphix, *Aphis punicae* (Passerini) appeared in large numbers on pomegranate around Bangalore. Collection of their natural enemies has yielded two parasitoids on *S. phillyreae* and four predators on *A. punicae*. Both the aphenlinids *Encarsia* sp. (Opulenta group) and *E. inaron* Walker had not been reported earlier on *S. phillyreae*. They were mainly responsible for suppression of the whiteflies. The predators namely *Scymnus casteenus* Sic, *S. latemaculatus* Motsch. *Menochilus sexmaculata* F. and *Paragus serratus* (F.) were also not recorded previously on *A. punicae* in India and elsewhere. Only *Scymnus* spp. were abundant helping in bringing down the population of *A. punicae* on pomegranate

Key words: Parasitoid, predator, *Siphoninus phillyreae*, *Aphis punicae*, pomegranate.

INTRODUCTION

Over 45 species of insects have been reported attacking pomegranate (*Punica granatum* L.) in India. The ash whitefly *Siphoninus ph illyreae* (Haliday) and the aphid *Aphis punicae* (Passerini) were also known to cause damage to pomegranate (Butani, 1976). Whiteflies remain in colonies mostly on the under surface of leaves and such the sap resulting in the appearances of chlorotic spots at feeding sites and ultimately shedding of severely infested leaves. They also secrete honeydew on which black sooty mould develops interfering photosynthesis of the affected leaves. Pomegranate aphids usually infest the tender leaves, flower buds and occasionally fruits. They also suck the cell sap and produce large quantities of honeydew making the plant parts sticky. Not much work has been done on these two insect pests in India. Both *S. phillyreae* and *A. punicae* appeared in larger numbers on pomegranate at I. I. H. R. Farm in 1989-92. Investigations were carried out to document their natural enemies and their impact in the suppression of these insect pests infesting pomegranate.

MATERIALS AND METHODS

Collection of natural enemies

Shoots infested with whiteflies and aphids were collected from the pomegranate orchards separately during 1989-1992. They were brought in cloth bags to the laboratory and kept in cloth walled wooden cages (30 x 30 x 30 cm). Parasitoids and predators that emerged were collected, preserved and sent to International Institute of Entomology, London for identification.

Impact of natural enemies

Whitefly: Infestation of whitefly was observed in Februafy '92 on 3 year-old-pomegranate plants. Three shoots (15 cm) per plant were collected and kept in cages at fortnightly interval. Sampling was done on five such infested

Contribution No. 15/93 of IIHR.

plants. Parasitoids that emerged in each sampling in the cages were collected and counted. Ten leaflets from the cage were also taken out and observed for parasitism. Parasitoids emerged through an irregular hole while whiteflies emerged through an inverted 'T' shaped hole (Natarajan *et al.*, 1986).

Aphids: The aphids were observed from July '92 onwards on 8-year-old pomegranate plants. The population of aphids and *Scymnus* larvae were observed on three tender leaflets per plant at fortnightly interval. Observations were taken on five such plants every time.

Results

Collection of natural enemies

Two years collection had yielded only two species of aphelinid parasitoids viz. *Encarsia inaron* Walker and *Encarsia* sp. (Opulenta gorup). No other parasitoid or predator was observed during the study period on pomegranate whitefly *S. phillyreae* (Table 1). *A. punicae* was found preyed by three coccinellids namely; *Scymnus castaneus* Sic., *S. latemaculatus (=guadrillum)* Motsch and *Menochilus sexmaculatus* F. and the syrphid, *Paragus serratus* (F.). However, no parasitoid has been recorded in the present study on pomegranate aphid.

Table 1. Emergence of *Encarsia* spp. and parasitism on *S. phillyreae*

Date	No. of *Encarsia* emerged/sample (Mean ± S.D.)	Per cent parasitism (Mean ± S.D.)
18-2-1992	37.40 ± 12.37	29.90 ± 5.16
4-3-1992	42.50 ± 17.24	42.30 ± 7.47
16-3-1992	55.70 ± 21.36	47.20 ± 10.30
2-4-1992	73.50 ± 18.27	54.40 ± 9.42
18-4-1992	86.60 ± 12.84	68.80 ± 12.76
3-5-1992	59.50 ± 24.29	71.00 ± 16.20
17-5-1992	28.70 ± 5.73	89.10 ± 11.27
1-6-1992	13.40 ± 2.64	92.30 ± 18.16

S. D. = Standard deviation

Impact of the natural enemies

The whitefly infestation was observed by the middle of February on pomegranate in Block No. 2. Regular sampling yielded large number of aphelinids (Encarsia spp.) upto May '92 (Table 1).. Maximum emergence (86.60) of *Encarsia* was observed from the samples collected on 18.4-1992. Parasitism by *Encarsia* spp., though was low initially in February but progressively increased in the subsequent months. Almost all the whitefly nymphs were found with parasitoid emergence holes in the first week of June. Whitefly ceased to be a pest on pomegranate mainly due to the activity of the local aphelinids.

Table 2. Population of *A. punicae* and *Scymnus* spp.

Date	Population of aphids/sample* (Mean ± S.D.)	Population of *Scymnus*/sample* (Mean ± S.D.)
15-7-1989	30.50 ± 12.46	2.00 ± 0.75
3-8-1989	52.30 ± 18.75	4.50 ± 1.36
17-8-1989	63.20 ± 20.34	7.30 ± 2.40
2-9-1989	17.30 ± 5.32	3.40 ± 0.68
16-9-1989	2.40 ± 0.50	0.70 ± 0.04

*3 leaves

Note: Negligible population of *M. sexmaculatus* and *P. serratus* were not included in the table.

Aphids appeared on the new flush in July '89. Subsequently they moved readily into flower buds. Aphid density reached in peak August with 63.20 aphids (Table 2). Aphid colonies had attraced a number of predators in the pomegranate orchards but not any parasitoid. Sometimes whole colonies of the pest were found completely destroyed by the predators. Predation by the larvae of *Scymnus* spp. played an important role in controlling the aphid infestation on pomegranate. But the population of *M. sexmaculata* and *P. serratus* was negligible. The aphids almost disappeared completely by the end of September mainly due to the activity of predators.

Discussion

Though *S. phillyreae* has been recorded on 60 plants species, pomegranate was known to support large whitefly populations (Bellows *et al.*, 1990). Unsatisfactory results have been

obtained with conventional pesticides in the control of whiteflies due to protective waxy coating over their bodies of the immature stages (Horowitz *et al.*, 1988, Johnson *et al.*, 1982). Insecticides on the other hand induced the outbreak of whiteflies due to the elimination of natural enemies (Natarajan *et al.*, 1986; Tremlay, 1969). Whiteflies including *S. phillyreae* have several effective natural enemies. Perusal of literature revealed that five parasitoids were known to attack *S. phyllireae*. Only *Encarsia galiea* Rivnay (Rivnay & Gerling, 1987). *E. partenopea* Mase (Priesner & Hosny, 1934) and *E. pseudopartenopea* Haliday (Viggiani & Mazzone, 1980) were reported earlier. Hence, the present record of *E. inaron* and *Encarsia* sp. (Opulenta group) appeared to be new records on *S. phillyreae* in India and elsewhere. Both the aphelinids were solely responsible for the suppression of whitefly. Natarajan *et al.*, (1986) also recorded upto 85% parasitism by aphelinids in yet another whitefly, *Bemesia tabaci* (Gennadius). According to Priesner & Hosny (1934), parasitism by *E. partenopea* reached 80% in *S. grantii* P & H in Egypt. The same parasitoid when introduced into California had substantial impact on the population of *S. phillyreae* (Bellows *et al.*, 1990). We could not observe any predator on *S. phillyreae* in the present study even though as many as six predators have been reported on the same whitefly species elsewhere.

Though *A. punicae* has been reported on pomegranate in USSR (Koshkarova and Zhigarevich, 1985), Portugal (Illharco, 1966), Persia (Theobald, 1920) and Egypt (El Nagar *et al.*, 1983), natural enemies (ie) predators were reported on *A. punicae* infesting hedges of Duranta in Egypt (Azab *et al.*, 1966). Hence, the present record of *S. castaneus, S. latemaculatus, M. sexmaculata* and *P. serratus* appeared to be new for *A. punicae* in India and elsewhere. In the present study, only *Scymnus* spp. were abundant and were responsible for the decline of aphid population. Similar observations on the abundance of *S. seriacus* and *S. interruptus*were recorded on *A. punicae* by Azab *et al.*, (1966). Though cecidomyiids and green lacewings were recorded earlier in Egypt, we could not get them on *A. pnicae* in the present study. So far, no parasitoid has been reported attacking *A. punicae* anywhere.

The fact that both *S. phyllyreae* and *A. punicae* did not become major pests on pomegranate in India revealed that the local natural enemies were able to operate effectively against them.

ACKNOWLEDGEMENTS

The authors are grateful to the Director, I. I. H. R., for providing facilities to conduct the study. They also acknowledge the help rendered by Mr. G. L. Pattar (Technical Officer) and Mr. S. Hanumantharaya (Technical Assistant) of I. I. H. R.

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ENTOMON 1995 VOL. 20 NO. 1 PP. 35 TO 39

Descriptions of the Nest and Immature Stages of *Heriades tolawasensis* Sharma & Gupta (Hymenoptera: Megachilidae: Osminii)

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Received on February 15, 1993

Abstract: The paper describes nest structure and immature stages of *Heriades tolawasensis* Sharma & Gupta. The nests were procured from some pre-excavated, vacant tubes of *Saccharum munia (=bengalensis)*, constructed by a mixture of fine sand, pebbles and resin. The study also details about different larval instars and cocoons reared from these nests.

Key words: nest, immature stages, *Heriades tolawasensis*.

INTRODUCTION

Wain (1966) described the bionomics of *Anthocopa matherenensis* Michener, mentioning it built the nest under deep crevices of a dried out pool, using chewed leaves and petals of *Mackenzia integrifolia* (Dalz.). This was the lone example of biological comments noted for any Osminii in this country. However, Bingham (1897) and Maxwell-Lefroy & Howlett (1909) have provided brief comments on the nesting biology of a few Megachilini. The study presented here details about the nest structure, immature stages and developmental comments on *Heriades tolawasensis* Sharma & Gupta.

Location of the Nests

Four nests, along with the adults, were colelcted on 4.5.1991 from Narainpur (Alwar). The area, deeply situated amidst the Sariska Reserve Forests, receives about 800 to 950 mm of annual rain-fall, temperature varies between 4°C to 42°C and RH ranging between 25% to 90%, throughout the year.

All the nests were procured from the hollow dead sticks of 'Moonj' (*Saccharum munja, = bengalensis)*, placed on the top of a hut at the height of about 2.5 meters from ground level, at the inclined angle of around 35° to 52° and aging about 7-8 months old. Using hollow sticks or woods for its nesting purpose was also reported by Fischer (1955) for *Hedriades variolosus*. Other species of tribe Osminii like those of *Hoplitis* prefers to construct masonary walls, under the soil, for its nesting purpose (Eickwort, 1973) and species of genus *Ashmeadiella* built their nests in the burrows under the soil (Rozen, 1987).

Nest Structure

The tubular shaped nests were built in pre-excavatged tubes, each with their opening end towards north or south. The vacant tubes were borrowed by *Heriades*, evidently due to the fact that they lack any cutting edges in between their mandibular teeth and secondly, their teeth are not so much incised to render them capability of excavation (Macial, 1981). This further got confirmation by one tube whose basal 1/3rd space, towards the blocked (nodal) end, was occupied by 4 dead, semi or fully developed adults of *Cerating propinqua* Cameron, the original builders of these tubes. Later, the 2/3rd vacant space, towards open end was reused by *Heriades*. Apparently, the former species failed to escape out due to the blocked end created by *Heriades*. Such excavation of tunnels by *Ceratina* species were also reported by Michener (1953), Kapil (1969) and McGinley (1981).

Fig. a describes a nest built upto nodal end

Table 1. Nest structure of *Hetrulex tolawasensis* Sharma & Gupta

	Nest character	Range	n	Mean
1.	Nest angle from horizontal	35° - 52°	4	45.75*
2.	Total length of tube upto nodal end, containing nest (cm)	11 - 14	4	12.25
3.	Percentage of the tube occupied by nest	51.42%-60.71	4	56.45%
4.	Outer diameter of stick (mm)	6.5 - 7.2	4	6.875
5.	Inner diameter of the tube (mm)	4.0 - 6.5	4	5.125
6.	Number of chambers per nest	8.0 - 16.0	4	13.0
7.	Outer length of the chamber (mm)	5.0 - 17.0	52	8.619
8.	Outer width of the cell (mm)	4.3 - 6.5	52	5.467
9.	Width of partition (mm)	0.2 - 1.5	36	0.7916
10.	Inner diameter of chamber (mm)	3.8 - 6.0	34	4.852
11.	Inner length of chamber (mm)	4.8 - 14.0	34	7.35

of the tube and Table 1 illustrates about the nest and chamber dimentions.

Normally 51.42 to 60.71% space of the vacant tube towards the open end, was found occupied. 25-34% space towards nodal end as 'air chamber' (except for one nest built upto node) and 24-26% space near the entrance, were left vacant. Fischer (1955) reported about 9mm space towards entrance in *H. variolosus* (Cresson).

Each nest conssits of linearly arranged chambers whose numbers varied from 8 to 16. The widths of chambers depended up on the inenr width of the tube, however, the lengths varied greatly measuring from 5 to 17 mm. Often the cell near the entrance was the longest one, filled with enough provisionings and was used as the guard cell by mother (one nes was collected with two females in this cell). All the cells were distinctly separated from each other by a partition or septa. (Fig. b).

The basal partition (close to node) was the thickest septum. It was almost uniformly thick (1.5 mm), slightly projecting towards node (Fig. c) and totally built of fine sand mixed with a few pebbles (total mass weight 0.03178 gm). Comparatively, rest of the intercellular septa were quite thin (0.2 mm) at their centres, projecting towards both margins, appearing much like the biconcave saucers. Thicker sides of these septa were built of fine sand mixed with resin but sand particles were rarely used at centre, leaving a very thin parchment like separation in between both cells. Resin seems to be the least used material in these partitions, however, each of them was supported by a few smaller pebbles and resin towards their either projections. Fischer (1955) has mentioned that this material acts as a bridge between the septum and the walls of either cells.

All the chambers were double walled (Fig. b). Outer wall built of resin, fine pebbles and sand and the inner wall consists of a very fine, thin, 'cellophane' like material, resembling that, used at the centres of the intercellular septa. Provision deposits were either deposited at the bottom or were glued to the lower margin of the partition and bottom. Most of the larvae were procured from this slope of food ranged between 0.01412 to 0.03178 gm (wet weight).

Immature Statges

Identification of the eggs in the nests could not be done. However, a few of the cells in each nest were found vacant or without any biological stages.

The number of larvae varied from 5-13 in each nest. In additon, a nest didn't contain any larva but it was collected with a female entering into it. At least 2 or 3 larvae, usually in the chambers near the nodal end, were not disturbed and were left in their cells under the 'cellophane' wall, for further observations.

The larvae collected from different nests, depicted certain distinct pattern of growth. Table 2 summarises about the size and weight of the larvae procured from nest no.1. The ascending pattern, from 13th to 3rd cell (except for those in cells 7th and 9th), apprehend that the process of oviposition took place from the

cells close to nodal cell which must be the first constructed one. A post-defecating larva was procured from the chamber no.2 after about 2 months but the larva in cell no.1 failed to spin cocoon due to unknown reasons and later desiccated.

Table 2. Weight and size of the contents found in the nest number 1 of *Heriades tolawarsensis*

Cell No. (from nodal end)	Content	Weight (gm)	Size (mm)
1	L	NT	NT
2	L (PD)	0.01218	6.80
3	L	0.01646	8.0
4	L	0.01608	7.85
5	L	0.01376	7.25
6	L	0.01346	7.20
7	L	0.00804	7.0
8	L	0.00958	6.25
9	L	0.00974	6.5
10	L	0.00886	6.35
11	L	0.00824	5.65
12	L	0.00658	5.0
13	L	0.00342	4.25
14	P	0.01412	
15	P	0.01728	
16	A (2♀)	NT	

A = Adults; L = Larva; L(PD) = Larva, post defecating; NT = Not taken; P = Provisionings.

Diagnostic characters

The diagnostic features of the larval morphology, in general coincided with those, described for the various Osminii larvae by Grandi (1935), Michener (1953), Matthew (1965), Mcginley (1981) and Rozen (1987).

Body dorso-laterally densely bristled, ventrally feebly or almost bare; intersegmental markings distinct up to the ventral surface; dorsal protuberences overcrossing the mid-doral line and reaching up to the lateral line, as in the species of *Ashmeadiella* (Michener, 1953). Other diagnostic characterts are-ventrolateral swellings slightly markabale; surfacial profile quite high above on dorso-lateral surface than the ventral surface; mandibles acutely bidentate; antennal papillae and palpi elongated and atria of spiracles with a few blunt teeth.

First/Second instar larva

Total body length 4.5 to 5.3 mm.

Head: Integument with very few setae and spicules; slightly pigmented at apico-lateral angles of labral sclerite; posterior thickening of head capsule well developed; cleavage lines and parietal bands absent; labral sclerite short, but anteriorly produced to lateral angles, medially invaginated, surface with two spicules, dentate margin of mandible pigmented, apices of both teeth rounded, outer tooth slightly exceeding inner in length, apical margin between teeth smooth, inner surface of apical half deeply concave; hypostomal ridge evident; apices of maxilla produced with a spicule at each stipes, maxillary palps quite short, maxillary lobes completely unpigmented; labium slightly projecting, divided into prementum and post mentum, with two palpi short, salivary opening a transverse slit at the apex of labium but unpigmented; hypopharynx not lobed.

Body: Robust, integument soft with very few bristles all over the dorsal surface; ventral surface smooth and bare; mid dorsal tubercles feebly markable on 4th to 7th segments and doesn't extend laterally; ventrolateral tubercles not evident; sexual characaters not identified and anus situated mid-posteriorly.

Mature larva: (Comparative comments with early instars).

Head: Integument with numerous setae and a few cylindricalspicules; apical margin of labral sclerite, mandibular teeth, salivary slit, prementum and basal sockets of antennal papillae pigmented; labral sclerite becomes wider, with 5 bristles, apico-lateral angles much produced; antennal papillae greater in length than basal width; mandible become more pigmented and teeth more prominently acute; maxillae rounded at pieces, palpus much produced; prementum of labium with three rows of three bristles at apical side and one row of two bristles near base; mentum bare; maxillae with 4 spicules, projecting anteriorly; mandible with one basal bristle; integument bare at ocular region.

Body: Much robust, surface dorso-laterally densely hairy but ventrall with sparse and fine bristles; dorso-lateral tubercles much prominent

bulging up to and on to the lateral line from segment 2 to pygidum; teeth in spiracular atria become distinct; ventral tubercles become distinct; sexual characters not identified and anus situated mid-dorsally with much swollen lips.

Measurements: Total body length 6.80; head-maximum length 0.74 and maximum width 0.82; distance ebtween antennal sockets 0.38, distance between antennal sockets and labral base 0.16 and length of mandibular outer margin 0.29 mm.

Post defecating larva: (Changes with relevance to mature larva) Head become much larger; body bristles much denser; dorso-lateral protuberences much produced, however, their prominency more confined to 2, 4, 6, 8 & 10th segments; ventro-lateral tubercles much bulged out; much produced lateralo-apical lobes of labrum completely conceal mandible (apical half) and apices of maxillae; mandibular teeth become robustly blunt and incised to form acute angles on inner & outer surfaces; bristles on head increased in number. Measurement: Total body length 7.2 to 8.0 mm.

Cocoon: Cocoons were formed during 10 to 16 July, 1991 when the temperature decreased to 32°C and RH increased to 90%. Only 3 larvae succeeded in spinning cocoons and rest failed to do so. It is most probably due to the disturbance in the 'Cellophane' layer during cleaning process of the cell wall. Thus the larvae in these cells got desiccated under adverse temperatures during June (around 40-44°C).

The cocoons were opened after 5 to 8 days of their formation. The oval shaped cocoons (Fig. J) were about 3.6 to 4.0 mm wide and 7.5 to 9.5 mm in length, weighing about 0.03206 to 0.03438 gm. Each is double walled, outer wall chitinous coloured and inner very thin like that of 'cellophane layer of cell', with lots of fibrous network. Much fibrous network was also reported in the cocoons of *Anthocopa matherenensis* but wall consists of 5 layers (Wain, 1966). At one end of cocoon a short circular disc of fibrous texture, about 2.78 mm in diameter, was found (Fig. K). The removal of this disc resulted in a fine micropyle of the cocoon. Inner surface of this 'micropylar lid' was further supported by another chitin coloured but stuffed disc, smaller (1.6 mm in dia.) and bearing a short protuberence at centre which fits in the micropyle of the cocoon. Numerous brown coloured and elliptical faecal pellets were found at the floor of the chambers when these cocoons were recovered out. All the cocoons were opened with postdefecating larvae, one of them has been described above.

Technique of Adult Emergence

The process of adult emergence was performed by perforating through the very thin centres of the intercellular septa like the method used by *Hoplitis* species (Eickwort, 1973). It was further confirmed by nest no.4 whose all the intercellular septa were bored through their centres thus making a thorough passage upto the entrance end. This nest was collected with a female in the guard cell and the vacant chambers were observed with empty puparia, faecal pellets and some particles of dried out provisionings. Perhaps, the remainings of the escaped offsprings of the previous generation. However, the basal partition of this nest was still intact.

Acknowledgements

Authors thank the Principal, R. R. Autonomous College and the Head of the Zoology Dept. of this College for laboratory facilities extended. Thanks are also due to Ms. S. Simlote for her assistance in the field and to Prof. V. N. Sharma for the literary presentation of this work. The work has been gratefully financed by ICAR, N. Delhi (Project No. 1-3/90pp).

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ENTOMON 1995 VOL. 20 NO. 1 PP. 41 TO 43

Biology of the red spider mite *Tetranychus cinnabarinus* (Boisd) - a pest of groundnut

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Received on March 31, 1993

Abstract: Under laboratory conditions the life-history, stages of the red spider mite, *Tetranychus cinnabarinus* (Boisd.) were: Egg period 3.28 days, 1st to 3rd instars of male and female respectively were 1.09, 1.11, 3.17 days and 1.12, 1.08 and 5.04 days. The duration from egg to death of adult was 10.39 days and 11.51 days respectively for male and female. The female reproduce parthegenitically as well as sexually. Average of 35 eggs were laid per female in five days. The male feeds on female of its own species and *Tetranychus hypogaea*, the white two spotted mite.

INTRODUCTION

The red spider mite is a minor pest of groundnut in India causing damage only in localized areas (Gupta and Sandhu, 1969). It was referred as *T. telarius* in literature wrongly and this is probably *T. cinnabarinus* (Amin, 1988). The mite infested leaves show stippling followed by light yellowing and finally almost white with brown patches. The damage was severe in crops that were under moisture stress, when complete drying of foliage occur. The mite infested plants show extensive webbing and tips of the plant appear reddish because of the assemblage of large number of mite on them. So far no information either on biology or on control of this mite was reported. We report for the first time the biology of this mite in groundnut.

MATERIALS AND METHODS

Life-history studies of *T. cinnabarinus* were studied in the laboratory at 30.37+2.27°C and 80.86+12.03% RH. Petri dishes were used as rearing cages. Whatman filter paper No.1 was used on the bottom of each dish and kept moist continuously. A single leaflet either from +3 or +4 leaves of main branch of cv. Girnar 1, grown in earthern pot, was placed keeping the upper surface upward. Adequate water was added to the petri dish so that the leaflet kept floating. A single female which normally bigger in size with robust abdomen from isogenic culture maintained in the laboratory, was released on the leaflet using a fine brush. Like this 20 petri dishes were maintained. The eggs laid by each female was recorded and isolated individually to single leaflet in small petri dish with filter paper in each petri dish and were numbered. Like this we have maintained only 50 petri dishes with individual egg for further observations on the emergence of nymphs and moulting. A reference culture was also maintained separately for making slides for morphometric measurement. The egg period was assessed from the egg laying to emergence of larva. Similarly the period of different instars were recorded till the death of the adult of both male and female. The mating, feeding and moulting and other observations were made using a dissection microscope. Measurements of different stages were made from the slides prepared from reference culture using a calibrated ocular micrometer. The leaflet in petri dish was replaced with fresh leaflet so that the mite will have fresh food source.

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Results and Discussion

The life stage of *T. cinnabarinus*, both male and female, include egg and three instars with an adult stage. Sexes were distinguishable even during immature stages. The duration of various stages of both male and female are shown in Table 1.

Egg: The eggs were deposited on both the surface of the leaflet over which webbings were made probably to prevent exposure of eggs for their natural enemies such as parasites belonging to Trichogrammatidae. During the course of this investigation a few of the egg parasites of *Trichogramma* tried to enter into the egg colony, however, due to extensive webbings they were prevented from moving towards the eggs. The eggs were dull white in colour, round in shape measuring 0.12mm diameter. Eggs were laid in groups however, they were separate from each other. The egg period lasted for 3.28 + 0.61 days for both male and female.

Table 1. Biology of the red spider mite *Tetranychus cinnabarinus* on groundnut

Instar	No.	Range	Mean±SD (days)
Egg	25	2 to 4	3.28 ± 0.61
Male:			
Larva	12	--	within 24h
Protonymph	12	1 to 2	1.09 ± 0.12
Deutronymph	12	1 to 2	1.11 ± 0.13
Adult	12	1 to 6	3.17 ± 1.15
Total life span	12	--	7.11 ± 2.15
Female:			
Larva	13	12h to 2	1.04 ± 0.08
Protonymph	13	12h to 2	1.12 ± 0.14
Deutronymph	13	1 to 2	1.08 ± 0.10
Adult	13	3 to 7	5.04 ± 2.14
Pre-oviposition	13	1 to 3	1.12 ± 0.08
Oviposition	13	1 to 5	2.22 ± 1.05
Post-oviposition	13	1 to 5	1.22 ± 1.05

Larva: The stage lasted for 1 and 1.04 days for male and female respectively to moult into protonymph. Newly emerged nymph of both the sexes possessed three pairs of legs. Male mite measured 0.1mm x 0.07 mm and females with 0.2 mm x 0.15 mm of length and width respectively. No difference could be seen in shape and size of both male and female mites excepting the abdomen. The casting off the old exuviae has taken place when the nymph became sedentary and probs its stylet into the leaf tissue. When the old exuviae was completely detached from new, the mite exerts its body upward. First there was a crack at the dorsal side just below propodosomal and due to further pressure, the exuviae got removed and the nymph came out of the exuviae and moves further in search of site for feeding.

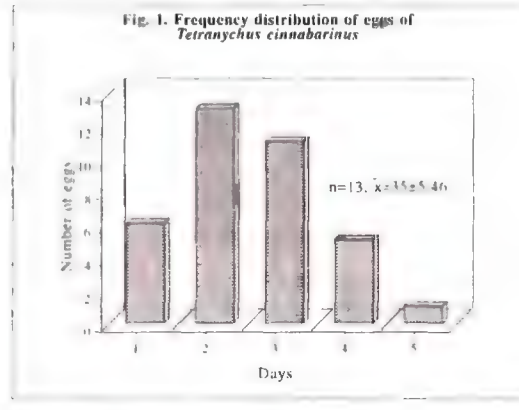

Fig. 1. Frequency distribution of eggs of *Tetranychus cinnabarinus*

The sedentary phase existed just for 5-6 h before moulting. This kind of observations were noticed in all instars.

Protonymph: Female took about 3 h more in completing this stage compared to male which took 1.11 days. The size of the female was increased by 20% from the protonymph while remarkable increase in size of the male could be noticed by 33%.

Deutonymph: This instar was important for female as the female attain 10% more the size of the protonymph. The abdomen showed almost robust due to ovarian development. The male increased in size by 25% and showed a clear distinction in terms of tapering abdomen towards anal. It was 1.11 days and 1.08 days respectively, to complete this stage, for male and female.

Adult: The adult male live for 3.17 days compared to female which lived on an average of 5.04 days which included pre-oviposition (1.12

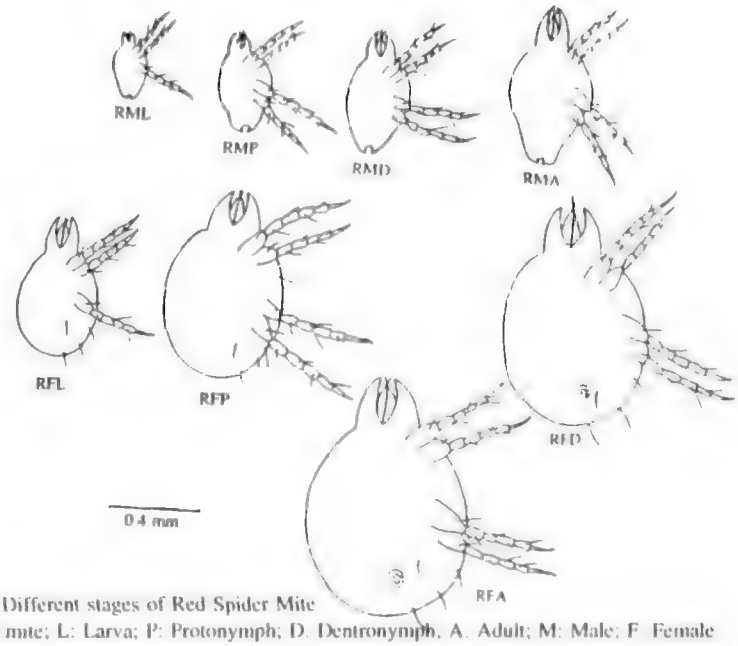

Fig. 2. Different stages of Red Spider Mite
R: Red mite; L: Larva; P: Protonymph; D: Dentronymph, A: Adult; M: Male; F: Female

days), oviposition (3 days) and followed by post-oviposition period of 1.22 days. The size of the female was 0.35 mm x 0.03 mm of length and width respectively. The male mates after a day of maturity. The female lays eggs immediately after becoming adult. Two types of reproduction were recorded. The female reproduce parthenogenetically as well as sexually. When the female become receptive to males, it stops moving and the male moves below the female in between legs of female and bends its anus upwards and transferred spermatophore with its spermatodactyl to the opening of the female's spermathecae. Males mate frequently with a few minutes interval, taking 17 to 24 seconds with an average of 20 seconds. The females, after egg laying, died instantly. The males predate on female of the same species and of *T. hypogaea*. The total life span from egg to death of adult was 10.3911.51+2.14 days respectively for male and female. They measured 0.25 mm x 0.3 mm of length and width. Each female laid an average of 35 + 5.46 eggs in its life span and maximum eggs were laid in the first 4 days, however oviposition lasted for 5 days (Fig.1). The different stages of both the sexes are given in Fig 2.

ACKNOWLEDGEMENT

The authors are grateful to Dr. P. S. Reddy, Director for facilities and encouragement, to Dr. M. Mohanasundaram, Professor and Head, Department of Entomology, TNAU, Coimbatore for identifying the mite and critically going through the manuscript.

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ENTOMON 1995 VOL. 20 NO. 1 PP. 45 TO 47

[Brief Communication]

A New Method for Observing the Hatching, Moulting and for Determining the Number of Larval Instars in *Goniozus nephantidis* Mues. (Hymenoptera: Bethylidae)

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Abstract: The larvae of *Goniozus nephantidis* Mues. (Bethylidae: Hymenoptera)ectoparasitic on the coconut pest, *Opisina arenosella* - Walk. (Aecophoridae: Lepidoptera) are static in their feeding disposition. Just as in any other bethylid, in this insect also, the processes of hatching and moulting are not easy to observe. Therefore, the determination of instars is also very difficult. A method is described here, wherein some inert coloured powder is used to locate the split portions of the chorion and moult skin. The serially located mandibular exuviae of the different larval instars on the ventrum along with the 5 sets of differently sized mesothoracic spiracles enabled the determination of larval instars as 5.

Key words: *Goniozus nephantidis, opisina arenosella*, biological control agent, larval instars, bethylids.

Goniozus nephantidis Mues. (Hymenoptera: Bethylidae) is a larval ecto-parasitoid of the black headed caterpillar pest of coconut, *Opisina arenosella* Walk. (Lepidoptera: Aecophoridae). In bethylids, a single feeding puncture is sued throughout the life of the larva (Clausen, 1940, Cushman and Gordh 1976 and Gordh, 1976). The larvae make feeding punctures and start feeding while inside the egg shell. Hence determination of exact time of egg hatch and the number of larval instars is highly difficult. The number of larval instars is known only for a few species. So far, there is no report of exact number of instars for any member of the *Goniozus* group. In the present study, the larval instars in *G. nephantidis*, is determined as 5. The observations pertaining to the determination here reported are considered as an ideal method to determine the hatching and moulting process in static bethylids.

The culture of *G. nephantidis* was maintained in the laboratory using host larvae of either *O. arenosella* or *Corcyra cephalonica* Staint. The mated female parasite after 4-5 days of preoviposition period was released into a glass tube provided with final instar larvae of the host and 50% honey. Soon after oviposition, the larva with eggs transferred to a petridish and the developmental stages were observed using stereo binocular microscope. The morphological changes of the spiracles and the mandibular exuviae were studied.

The larva inside the egg makes a hole on the ventral side of the chorion just at the point of mandibles and then cuts the host cuticle with the 2 pointed mandibles to make a feeding puncture and starts sucking host haemolymph. Hence the slight movement in the head region marks the starting of hatching and the beginning of the 1st larval instar. The process of

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[1] The findings are from the Ph. D thesis of the author

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hatching was studied by applying very fine inert red colour powder on 24 hour old egg using a fine brush. It was observed that as the feeding of the larva proceeded, there appeared a longitudinal clear area on both the dorsolateral sides of the egg exposing the lateral tracheal trunks and spiracles. This proved that the chorion splits on the lateral sides above the lateral trunk region. As the growth proceeded the width of the clear area increased leaving a coloured dorsal strip of chorion. This strip of coloured portion remained on the dorsum for a long time. Hence further moults could not be studied till a later stage when it has moved anteriorly.

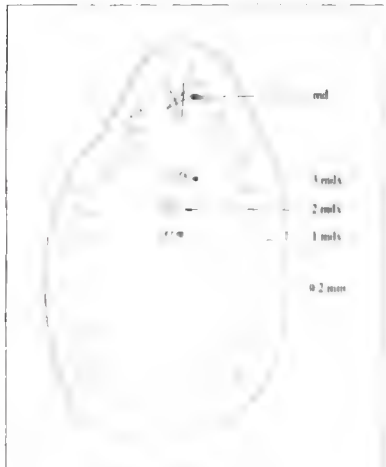

Fig.1. Ventral view of a fourth instar larva of *G. nephantidis*. 1mdx-Mandibular exuvium of first instar; 2mdx-Mandibular exuvium of second instar; 3mdx-Mandibular exuvium of third instar; md-Mandibles of the fourth instar larva.

When the dorsal coloured strip moved anteriorly occupying only the head dorsum, fine green coloured powder was applied on the clear dorsum. It was observed after a few hours that the powder has parted and moved towards both the sides showing that a dorso median split has formed and the skin has moved lateroventrally. Further to this, red powder was applied on the dorsum which never parted sideways, but spread on the whole surface showing mere growth and no further moulting. This study revealed that the chorion remains on the larval dorsum till it reaches the penultimate instar. Even in the early last larval stage, the chorion remained on the head. Due to extensive feeding, when the larval head penetrates deep into the host, the parts of chorion and exuvial remnants get removed leaving a clear integument.

After extensive observations on the morphological aspects of the growing larvae, it was found out that the mandibular exuvium of each stage is deposited in a serial fashion just on the ventral side of the body. By counting the number of the pairs of the mandibular exuviae, the stage of the larva was determined. The mandibular exuviae of stages upto 3rd were visible on the larval ventrum (Fig. 1). As the movement of the mandibular exuviae were posteriad, the exuvium of the 1st instar was the posterior most, next to that being that of the 2nd instar and the one nearest to the mouth parts belonging to the 3rd instar. The fourth instar exuvium does not remain attached to the ventrum because all the chorionic and exuvial remnants are removed from the larval body by the penetration of the larval head into the host and lifting of the body to attain a vertical position on the host. The dorsal chorionic parts along with head exuvium were removed anteriorly and the remaining chorionic portions together with exuviae get attached to the host cuticle as a thin pad on the surface which was occupied by the parasitoid upto its fourth instar.

Table 1. Morphometry of the mandible and spiracle of the larval instars of *G. nephantidis*

Larval instar	Mandible length (mm)	Diameter of the meso-thoraic spiracle (mm)
1	0.041 ± 0.0040	0.0043 ± 0.0014
2	0.0436 ± 0.0029	0.0074 ± 0.0016
3	0.0470 ± 0.0010	0.0092 ± 0.0010
4	0.0513 ± 0.0041	0.0113 ± 0.0006
5	0.0530 ± 0.0010	0.0302 ± 0.0016

The observations on the mandibular exuviae, measurements of the mandibles and mesothoracic spiracles (Table 1) revealed that there are 5 instars in this bethylid. Nickles (1950)

described 3 stages in *P. cellularis* var. *puncta ticeps*. Gordh (1976) reported that *p. gallicola* has at least 3 instars and possibly a 4th one as well. By the morphological appearance of the larvae it was though that *G. nephantidis* has only three instars (Remadevi *et al.*, 1981). The observat-ions on the mandibular exuviae and the morphometry of the mandibles and mesothoracic spiracles have enabled the ascertainment of the instar numbers as five. So far there is no report on the exact number of instars for any species of *Goniozus*. The methods of observation described here may be useful in determining the instars in other *Goniozus* species.

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[Brief Communication]

Carbohydrate Contents at The Primary Active Sites of Nuclear Polyhedrosis Infection in the Armyworm *Mythimna (Pseudaletia) separata*

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Received on Febrary 2, 1992

Abstract: During nuclear polyhedrosis the fat body, gut and integument indicated hypoglycemia, whereas the haemolymph demonstrated the hypertrehalosemia and hyperglycemia These changes were similar to the ones observed during starvation, but hypertrehalosemia was more evident than hyperglycemia during starvation.

Key words: Nuclear Polyhedrosis, *Mythimna (Pseudaletia), separata* hypoglycemia, hypertrehalosemia, hyperglycemia.

Changes in carbohydrate contents in the body of the host insects like *Lambdina fiscellaria somniaria, Melolontha melolontha* and *Heliothis virescens* during cytoplasmic polyhedrosis virus (CPV) infections (Morris, 1962, 1966; Thompson and Sikorowski, 1980) have already been reported. However, there is no information about such variations caused by the nuclear polyhedrosis virus (NPV) at the primary active sites of infection like fat body, gut, integument and haemolymph. Therefore, the present studies were undertaken to note the pathophysiology of the nuclear polyhedrosis in the notorious pest, *Mythimna (Pseudaletia) separata.*

The 3rd instar army works were inoculated with LC_{25}, LC_{50}, LC_{75} & LC_{95} strong NPV to estimate the changes in glycogen and glucose contents of the fat body, gut and integument at 24 hour intervals, during the first five days of the treatment. Further, the concurrent variations in trehalose and glucose contents of the haemolymph were also noted to appreciate the follow up of the possible poyhedrosis contraction. Moreover, in order to differentiate the starvation effect from the effect of nuclear polyhedrosis, a group of starved armyworms were also kept under observation.

The glycogen (Shimada *et al.*, 1984), and glucose and trehalose (Kramer *et al.*, 1978) were separated and estimated as per the Van Der Vies (1954) and Roe (1955), respectively.

During the nuclear polyhedrosis, the glycogen and glucose contents of the target tissues decreased, perhaps, concurrently increasing haemolymph trehalose and glucose. Interestingly, during starvation also similar changes were observed (Figures, 1, 2, 3 & 4).

The depletion of tissue glycogen at the fat body, gut and integument was perhaps due to the progress of the nuclear polyhedrosis. The carbohydrates like glycogen and glucose were utilized possibly for the growth, multiplication and maturation of the pathogen. However, during starvation the glycogen was withdrawn from the tissues perhaps to meet the energy demands of the body.

Possibly, hyperglycemia and hypertrehalosemia, observed during nuclear polyhedrosis, indicated the presence of a stress as well as the starvation. A corpus cardiacum factor, trehalagon is reported to cause the glycogenolysis at the fat body leading to the haemolymph hyperglycemia (Steele & Paul, 1985). Further, the nuclear polyhedrosis is known to reduce the consumption of food in cabbage loopers

Fig. 1. Variation in glycogen content of the fat body in *M. (P) separata* during nuclear polyhedrosis

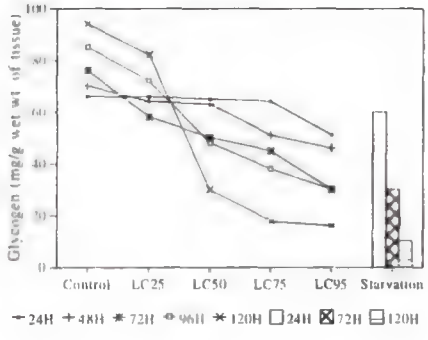


Fig. 2. Variation in glucose content of the fat body in *M. (P) separata* during nuclear polyhedrosis

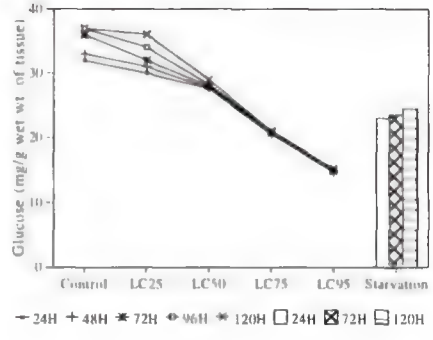


Fig. 3. Effect of nuclear polyhedrosis on haemolymph trehalose in *M. (P) separata*

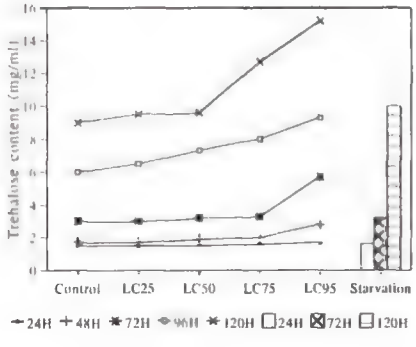
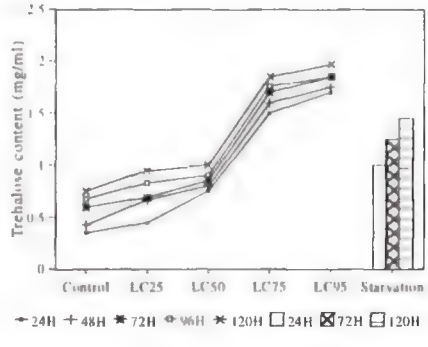


Fig. 4. Effect of nuclear polyhedrosis on haemolymph glucose in *M. (P) separata*



(Harper, 1973). Moreover, the stress in the form of excitation lead to hyperglycemia and hypertrehalosemia (Downer, 1979). Possibly, therefore, a similar situation is created in the armyworm *M. (P.) separata* during the pathogenesis of nuclear polyhedrosis because of the combined effect of induced stress, excitation and starvation. Hence the changes in the carbohydrate contents at the primary sites of active polyhedrosis infection suggest that the onset of the disease might initiate glycogenolysis leading to hyperglycemia and hypertrehalosemia in the haemolymph, possibly through excitation of the host or through the starvation which might have been secondarily induced due to the contraction of the disease.

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[Brief Communication]

Studies on the Efficacy of Sodium Hydroxide as Prophylactic Agent Against Polyhedrosis in Tasar Silkworm, *Antheraea mylitta* Druary

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Received on October 25, 1993

Abstract: Experiments were undertaken to study the efficacy of NaOH against polyhedrosis of tasar silkworm, *Antheraea mylitta* Druary. The foliar spray of 0.5% NaOH significantly (P<0.01) reduced disease mortality and increased effective rate of rearing. The concentration tested had no adverse effect on the survival of silkworms, cocoon weight, shell weight and shell ratio (%). The prophylactic activity of the chemical had a second line of defense against polyhedrosis.

Key Words: Polyhedrosis, tasar silkworm, *Antheraea mylitta*, Sodium hydroxide, prophylactic agent.

The tasar silkworm, *Antheraea mylitta* D., an economically important sericigenous insect suffers about 20% disease mortality due to the infection of polyhedrosis virus in tropical tasar growing belts of India. Some prophylactic agents have been reported to combat polyhedrosis in mulberry silkworm, *Bombyx mori L.* (Nomani & Mukherjee, 1975; Patil, 1991). But no prophylactic agents have been evolved against polyhedrosis of tasar silkworm, *A. mylitta*. In the present investigation the efficacy of Sodium hydroxide as prophylactic agent has been assessed against polyhedral infection of tasar silkworm in both seed as well as commercial crop rearings.

The eggs of *A. mylitta* obtained till 24 hrs of oviposition were disinfected with 5% formalin for 5 minutes following the standard disinfection methods being commonly practiced in Indian Tasar Culture. After disinfection, the eggs were thoroughly washed with distilled water and incubated at 28°C and 78% relative humidity. Hatched larvae were reared in indoor conditions with twigs of Asan, *Terminalia tomentosa* following the out door rearing as per standard rearing packages evolved by Central Tasar Research & Training Institute, Ranchi, India. During II instar after rearing for 24 hrs, the food plants were sprayed along with worms with three concentrations of NaOH (B.D.H., Product) i. e. 0.5%, 1% & 2%. Five replications, 100 worms in each replication were kept for each concentrations. An identical control batch was also reared by spraying distilled water. Spraying of NaOH solutions was conducted after each and every transfer /24 hrs of moulting. Since the survival of worms treated with 1% & 2% NaOH was adversely affected, it was felt imperative here to study the efficacy of only 0.5% NaOH as prophylactic agent. Observations were also recorded for viral mortality, Effective Rate of Rearing (E. R. R), Shell weight and Shell Ratio (S. R%) for both seed as well as commercial crop rearings. Viral mortality was assessed by examining all dead worms microscopically for Polyhedral Inclusion Bodies (P. I. B.).

Effect of foliar spray of 0.5% NaOH on tasar silkworm rearing is presented in Table 1. The chemical had significantly (P<0.01) reduced the polyhedrosis and thereby helped in enhancing the Effective Rate of Rearing significantly (P<0.01) in both seed as well as commercial crop rearings. Thus, the chemical had got its prophylactic effect on tasar silkworm rearing. Efficacy of a prophylactic mixture

Table 1. Effect of foliar spray of 0.5 NaOH on tasar silkworm

Rearing season	Treatments	Viral mortality (%)	Effective rate of rearing (%)	Single cocoon weight (g)	Single shell weight (g)	Shell ratio (%)
Seed crop rearing, 19c	NaOH (0.5%)	17.70±0.61**	46.60±1.01**	12.47±0.33NS	1.63±0.01NS	13.09±0.11NS
	Control	24.40±1.14	35.70±0.23	12.46±0.084	1.65±0.01	13.26±0.64
Commercial crop rearing	NaOH (0.5%)	11.30±0.202**	71.20±0.528**	11.67±0.483NS	1.63±0.001NS	14.04±0.11NS
	Control	24.80±0.564	47.90±0.23	11.99±0.004	1.78±0.001	14.89±0.005

Values indicate mean of 5 replicates ± SE
** Significant at 1% level
NS Non-significant

(Papazol) in reducing viral mortality and increasing Effective Rate of Rearing of *B. mori* has also been reported by Nomani & Mukherjee (1975). Patil (1991) in his experiment observed that Calcium Hydroxide when fed preorally decreased the incidence of cytoplasmic polyhedrosis of silkworm, *B. mori* and increased Effective Rate of Rearing.

It is also clear that the spraying of chemical had no adverse effect on Cocoon weight, Shell weight and Shell Ratio % in both seed as well as commercial crop rearings. Further, the record of 24.40% to 24.80% viral mortality in control lots for seed as well as commercial crop rearings respectively, clearly depicts that egg surface disinfection with 5% Formalin for 5 minutes being widely practiced in Indian Tasar Culture is not helpful in reducing viral mortality for rearing in outdoor conditions being exposed to different predisposing factors like high temperature and high humidity. Vail *et al.*, (1968) also found that Formalin when used as egg surface disinfectant, had little effect on larval recovery during rearing of the cabbage looper, *Tricoplusia ni* being infected with polyhedrosis virus.

Since, the tasar silkworm rearing is reared in outdoor conditions, there is every possibility for silkworm larvae to get infected either through food or other source of contaminations. Once a few worms are infected, secondary infections take place through excreta or by direct contact. Therefore, a second line of defense against these secondary infections is essential and it is apparent from the results that application of 0.5% Sodium Hydroxide as prophylactic agent on tasar silkworms is quite effective to check the secondary infections caused by polyhedrosis besides doing normal egg disinfection with 5% Formalin.

ACKNOWLEDGEMENTS

The authors are grateful to the Director, Central Tasar Research & Training Institute, Ranchi for constant encouragement.

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[Brief Communication]

Sex Determination of *Etiella Zinckenella* Treitschke at Different Developmental Stages

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Recieved on October 30, 1992

Abstract: Morphological characters for the determination of sex in *Entiella zinckenella* Treitschke (Lepidoptera: Phycitidae) at different developmental stages have been determined and illustrated. The anal and genital openings are more closely placed and wing pads are longer in male pupae than in female. A pedicellar projection at the inner margin, longest II flagellar and small III labial segments are most diagnostic features in the male moths to differentiate from the female moths which lack pedicellar projection and have comparatively smaller II flagellar and long III labial segments.

Key Words: Sex determination, *Entiella zinckenella*, pupal wing pads, pedicellar projection.

Etiella zinckenella Treitschke is one of the important pests of lentil and pea. In insects the sex determination is an important pre-requisite in laboratory and field experimentations for their control as well as in the viably integrated pest management programmes. In Lepidoptera, the males and females are generally separated on the basis of some external morphological characteristics of pupae (Jackson, 1890; Poulton, 1890). Afterwards, the sex determination was done in some families of Lepidoptera at pupal stage (Solomon, 1962; Petrson, 1865 & Qureshi *et al.*, 1986). Therefore, attempts were made to segregate the males and females of *E. zinckenella* at pupal as well as adult stages by considering their differentiating morphological characteristics.

The stock culture of *E. zinckenella* was maintained in the laboratory on its natural foods (pea and lentil). Studies on different morphological characters to differentiate the males and females at the pupal as well as adult stages were made under a Zoom-Stereoscopic binocular microscope.

The males and females of *E. zinckenella* were distinguished at the following two stages of development.

a. Pupal stage: The sexes of *E. zinckenella* at the pupal stage were isolated on the basis of interocular distance, length of wing pads and the distance between anal and genital openings. The interocular distance is less in female pupa than in male and the wing pads of the latter are longer than the former i.e. extended more on to IVth abdominal Segment (Fig.1, i & ii). In both the sexes the genital and anal openings are situated mid-ventrally. In male pupa, the genital opening is present on the IXth abdominal segment while in female it is located on the VIIIth segment just beneath the intersegmental suture between VII and VIII segments. The anal opening is present on the tenth abdominal segment in both the sexes. Therefore, the distance between the anal and genital openings is more in the female than in the male (Fig.1, i&ii and Table 1) and this is considered to be the most distinguishing feature. Differences in the position of genital openings have been used earlier in sexing the pupae of the elm spanworm (Solomon, 1962), codling moth (Petrson, 1965) and *Amsacta moorei* (Qureshi *et al.*, 1986) which support the present findings.

b. Adult stage: The sexes of *E. zinckenella* in adult stages were determined on the basis of

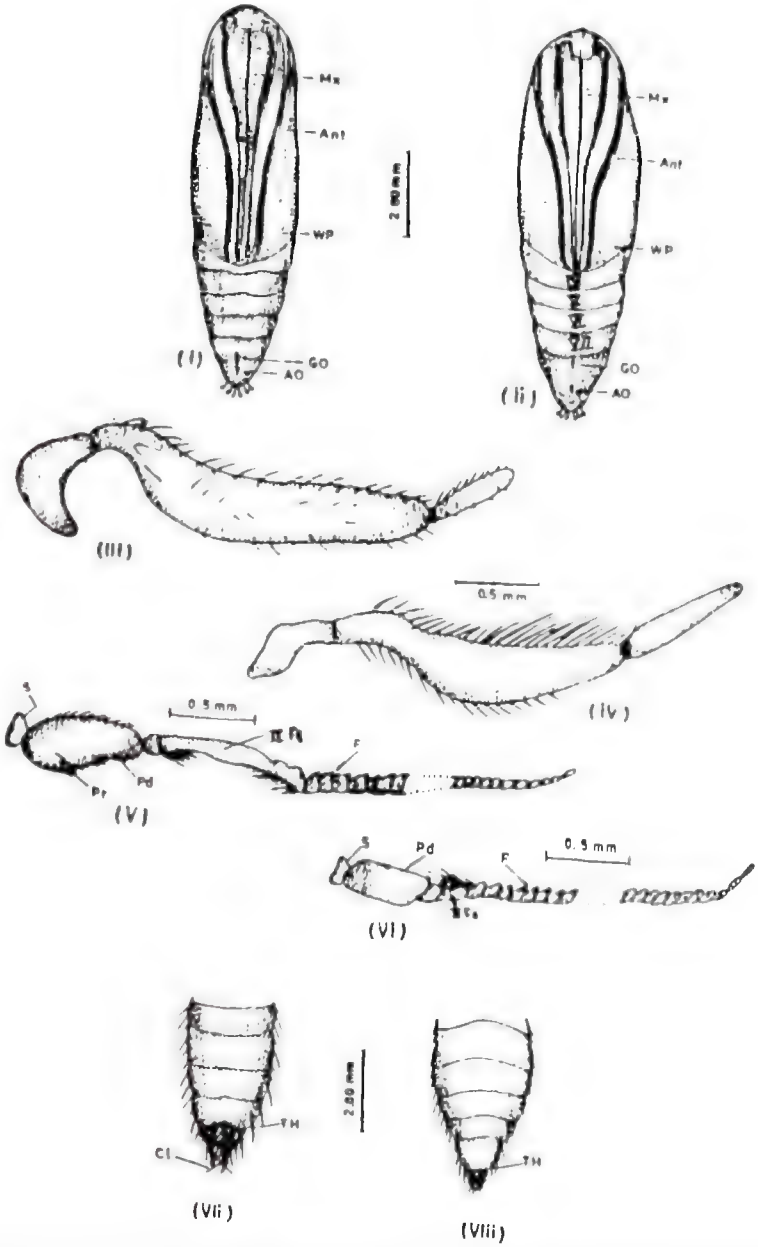

Fig. 1. Sex determination of *Etiella zinckenella* at different development stages; i. Male pupa; ii. Female pupa; iii. Labial pal (male moth); iv. Labial palp (Female moth); v. Antenna (Male moth); vi. Antenna (Female moth); vii. Abdomen (Male moth); viii. Abdomen (Female moth).

Abbreviations: Ant-Antenna; AO-Anal opening; Cl-Clasper; F-Flagellum; GO-Genital opening; MX-Maxilla; Pd-Pedicel; Pr-Projection; S-Scape; II Fs-Second flagellar segment; TH-Tuft of hair; WP-Wing pad

structure of the antennae, labial palpi, and size of moths. In case of male moth, the pedicel (Pd) of each antenna is broadened at the base and have a projection (r) at its inner margin. Its second flagellar segment is large, curved and provided with long hairs (Fig.1, v). In the case of females, the antennal projection of the pedicel is absent and the second flagellar segment is much smaller as compared to that of male (Fig.1, vi). The first and second labial segments are longer, broader and comparatively more curved in the male than that of the female moths, while the third labial segment is longer in the latter (Fig. 1, iii & iv). The abdomen of male moth is narrow and provided with yellowish irregular tufts of hairs at the anal end. The claspers are visible at the posterior end of abdomen. In the female moth, the abdomen is broad with tufts of yellowish hairs of regular length at the posterior end (Fig. 1, vii & viii). Average body length and width are greater in male than in the female (Table 1). The present findings derive support from the work of Dhooria and Singh (1971) who distinguished the sexes on the basis of structure of antennae and three segmented labial palp was longer in male moth.

Table 1. Morphometric variations in male and female pupae and adults of *Eteilla zinckenella*

Characters	Pupae	
	Male	Female
Distance between anal genital openings (mm)	0.214±0.031	0.427±0.029
Length of pupae (mm)	8.670±0.230	8.830±0.210
	Adult	
Average body length (mm)	12.18±0.21	11.32±0.12
Average body width* (mm)	22.16±0.24	21.24±0.24

±SE (Mean of 10 observations)
*Across wing expanse

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[Brief Communication]

Life Table Studies of Tropical Tasar Silkworm *Antheraea mylitta* (Lepidoptera: Saturniidae)

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Received on October 30, 1992

Abstract: Life table studies of Tropical Tasar Silkworm *Antheraea mylitta* Drury indicate net reproductive rate (RO) representing the total female birth rate at 113.30. The population increases with an infinitesimal rate (rm) of 0.0583 and finite rate (λ) of 1.060 per female per day. The first generation is completed in 81 days indicating slower rate of population build up.

Key Words: Life table, Fecundity, *Antheraea mylitta* D., Saturniidae.

Life table is one of the most useful numerical aids for the study of population biology (South Wood, 1978) particularly to determine age distribution and mortality rate in natural population. Such studies help in assessing the values of various ingredients of the environment which are responsible for maintenance of a population in nature. Life table studies have been used to evaluate varieties of castor for rearing of eri silkworm *Philosamia ricini* Hutt. (Joshi and Mishra, 1985). Present work was undertaken to study the various life history parameters viz, timing and reproduction rate, survival rate, offspring quality, and intrinsic rate of increase. This is the first study to report the life table of *A. mylitta.* The experiment was conducted at Central Tasar Research and Training Institute, Ranchi during first crop (July-Aug.) 1991. Known number of adult pairs of *A. mylitta* emerged from Daba bivoltine cocoons were kept for egg laying in perforated plastic egg laying boxes (7x5, 5x3 cm). Eggs laid on first day were collected and 100 eggs per replication were kept for hatching and replicated ten times. Immediately after hatching the larvae were reared indoor on the leaves of *T. arjuna* in plastic boxes. After three days the larvae were transferred to the host plants in outdoor and reared upto spinning of cocoons. The harvested cocoons were kept for seed production. The temperature and relative humidity ranged were 24° to 28°C and 76 to 90% respectively and recorded in situ daily at eight hours interval. To find out fecundity, the adults emerged on a particular day were paired and released in plastic boxes for oviposition. The eggs laid by females were noted every day till the death of the moths. Observations from hatching of eggs till emergence of adults were recorded daily which provided value for working out the life table. Sex ratio (M: F) observed was 40: 60. Life table was constructed according to the method of Birch (1948) and Atwal and Bains (1974).

The life table showing survivorships (1x), mortality rate (qx) and life expectancy (ex) etc, (table 1 & 2) indicate that at the beginning of age class interval when the eggs were laid the expectancy of life is nearly 52 days for tasar silkmoth it is 11 days which decreases continuously as the age of the moth advances showing uniform mortality rate. Similar pattern of life expectancy was reported for adults of mountain sheep (Deevey, 1947) and gray squirrel (Barkalow, *et al.,* 1970). The survival of individuals (lx) on the completion of pupation was 48 days which is quite lower as compared to that of Eri silkworm, *P. ricini.* Hutt, (Joshi and Mishra, 1985). The reason for low lx value in *A. mylitta* may be attributed to outdoor larval rearing where pests, predators and diseases cause heavy larval mortality besides abiotic factors (Sen and

Jolly, 1967). This becomes evident from mortality rate (qx) which comes to 0.46 (Table 1) in entire larval phenology. Maximum mortality rate of 0.27 was observed in the final instar of the larvae mostly due to a virus disease (virosis). Incidence of virosis has been reported to be most prevalent when there is sudden fluctuation in relative humidity and temperature during rearing (Sen *et al.*, 1969).

Table 1. Life Table and net reproduction rate of tasar silkmoth, *Antheraea mylitta*

Age in days	Age specific survival rate	Total progeny	Natality rate	Net replacement (reproduction) rate	
x	lxl	mxl	mx	lxl.mx	lxl.mx
81	0.42	6456	162.00	68.04	5511.24
82	0.42	1976	52.00	21.24	1790.88
83	0.40	1444	38.00	15.20	1261.60
84	0.21	770	22.00	4.62	388.08
85	0.18	368	16.00	2.88	244.80
86	0.10	120	6.00	0.60	51.60
87	0.08	12	1.50	0.12	10.44
88	0.02				

Potential fecudity (PF) = Σmx = 297.50
Net replacement rate (RO) = ΣlxI.mx = 113.30

The age specific survival lx (Table 2) for females was observed to be 0.42 which gradually reduced to 002 on 88th day. The first female mortality within the cohort was noted on day 3 after the adult emergence and mortality increased thereafter. The female contributed the higher egg production (mx= 162) on the first day after copulation and on 81st day of the life cycle. The lowest egg production (mx=1.50) was on 87th day of the pivotal age (table 2). T his trend of egg production is similar to that observed in *P. ricini* (Joshi and Mishra, 1985) and in *A. mylitta* (Thangavelu *et al.*, 1992) for first three days. A female moth was found to lay approximately 298 eggs till it perished. The net replacement rate (RO) was 113.30 (table 2) which is more than that of Eri silkmoth, *P. ricini* where it ranges between 90 to 61, (Joshi and Mishra, 1985). This is due to the fact that in *a. mylitta.* the sex ratio is skewed towards female. It is evident (table-2) that the rate is maximum on first day of oviposition, reducing thereafter. The decreasing pattern of RO with age of the female is a common phenomenon observed in other insects such as *P. ricini* (Joshi and Mishra, 1985) and *Calendra oryzae* (Birch, 1948).

The innate capacity of increase (rm) was observed to be 0.0583 (table-3). The value of rm was low compared to insects relatively smaller in size as like *Corcyra cephalonica* (Teotia and Singh, 1975), *Trogoderma oranrium* (Atwal *et al.*, 1968) etc. According to Brich (1948) the large insects would require a longer time to complete development and this operates to reduce the value of rm. Our studies corroborates these findings.

Table 2. Mean length of generation, innate capacity for increase in number and finite rate of increase in number in *Antheraea mylitta*

Sl. No.	Particulars		Value
1.	Mean length of generation	Tc	81.72 days
2.	Innate capacity for increase in number	rc	0.0578
3.	Now. arbitrary rm (rc) are 0.068 & 0.08	λ	0.0583
4.	Finite rate of increase in number	T	1.060
5.	Corrected generation time	(λ)	81.13
6.	Rate of weekly multiplication		1.534

The finite rate (λ) for increase in number was 1.060. At this rate the population was capable of multiplying 1.504 times per week under given set of conditions. Lower innate rate of increase, and longer generation time contributed to slower build up of *A. mylitta* population in nature.

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[Brief Communication]

First Record of the Aphix Parasitoid *Archaphidus greenideae* Stary & Schlinger (Hymenoptera: Aphidiidae) From India

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Received on December 19, 1992

Abstract: Aphid parasitoid, *Archaphidus greenideae* has been recorded for the first time from India on *Greenidea ficicola* Takahashi infesting *Psidium guajava*.

Key Words: First record, *Archaphidus greenideae, Greenidea ficicola, Psidium guajava*

Extensive survey for aphids and their natural enemies in terai belt of northeastern Uttar Pradesh during 1990-1992 revealed the presence of 25 species of aphids, 13 species of their parasitoids and 5 species of hyperparasitoids. Among these we found one species of parasitoid, *Archaphidus greenideae* Stary & Schlinger on an aphid, *Greenidia ficicola* Takahashi (Homoptera: Aphididae) infesting *Psidium guajava* during December, 1991 when the collected aphids from Kushumhi forest were reared in the Laboratory. Unfortunately, we found only one female from a large reared sample. Stary and Schlinger (1967) had described the species from a single specimen reared from *G. ficicola* in Taiwan. Later on, another single female was recorded on another aphid host *G. formosana* (Maki) infesting *P. guajava* by Stary and van Harten (1983) from Bangladesh. It was also redescribed by them. There is no previous record of this species form India.

ACKNOWLEDGEMENTS

We thank Dr. B. K. Agarwala, Department of Life Sciences, Tripura University, Agartala for identification of aphids and UGC, New Delhi for furnishing financial support.

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[Brief Communication]

Occurrence of the Mealy Bug *Pseudococcus saccharicola* Takahashi (Homoptera: Pseudococcidae) on Sugarcane, *Saccharum officinarum* Linnaeus-A New Record from the Andaman Islands, India

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Received on December 19, 1992

Pseudococcus saccharicola has been reported for the first time from Andaman.
Key words: *Pseudococcus saccharicola*, sugarcane, Andamans.

Sugarcane (*Saccharum officinarum* L.: Poaceae) was introduced by the British to Andaman islands for cultivation by convicts prior to 1866 (Prain, 1890). Known to perform well on these is lands (Rangaswamy Ayyangar, 1946) it is today the fourth most important crop of the islands in terms of area cultivated, next only to coconut, rice and bananas (Anon., 1991).

During the course of an ongoing survey for the insect pests of agri-hort-silvicultural crops on these islands *Pseudococcus saccharicola* Takahashi was found on the leaves of sugarcane in field on the outskirts of Port Blair, South Andaman in October, 1990. Though known to be distributed widely in the South and South-east Asian region-commencing from mainland India in the west, through Bangladesh, Thailand, Malaysia, Philippines and Formosa, to Papua New Guinea in the east-this pest was not until now known to occur on the Andaman isles. Only three species of pseudococcids have in fact been recorded so far from these islands (Varshney, 1982). *P. saccharicola* is known to extensively damage and even kill young sugarcane plants. The older plants however do not succumb to attack by this pest but exhibit characteristic yellow blotches on the leaves (Watson, 1991).

Other grasses including *Saccharum arundinaceum* Retz. which are native to these islands (Rao, 1986) are known alternate hosts of *P. saccharicola* (Watson, 1991). It therefore seems more likely that the mealy bug too is native, and has not been introduced along with sugarcane, to these islands. It has not so far been collected on rice (*Oryza sativa L.*) which, like sugarcane was introduced to these islands before 1866 (Prain, 1890) and is known to be yet another alternate host (Watson, 1991).

Acknowledgement

We are grateful to Dr. A. K. Bandyopadhyay, Director, C. A. R. I., Port Blair, for encouragement and Dr. G. W. Watson, I. I. E., London, for the identification of the insect.

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[Brief Communication]

First Report of the incidence of *Oberea artocarpi* Gardner (Cerambycidae: Coleoptera) on mulberry

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Recieved on August 7, 1992

Abstract: Incidence of univoltine Cerambycidae *Oberea artocarpi* Gardner has been reported for the first time on mulberry. Larvae bore in to the stems and adults feed on the leaves.

Key words: *Oberea artocarpi* Gardner, stem borer, mulberri

Oberea artocarpi Gardner has been found to be boring the stems of mulberry in Kerala. Incidence of this pest has been noticed in Alappuzha District since 1990. *O. artocarpi* was first described by Gardner 91941) from Palakkad, Kerala. The specimens described by Gardner were reared from green twigs of *Artocarpus integrifolia*. No other host plant of the insect was so far known. Biology and nature of damage of the pest were observed over a period of one year from June 1990.

Biology

Biology and habits of the pest were more or less similar to that of *Olateapicalis* Pic. on citrus (Bhumannavar and Singh,. 1983). Adult emergence started before premonsoon showers from the third week of February as against the second week of April by the commencement of premonsoon showers in the case of *O. lateapicalis*. Adults were present in the field up to the last week of June. Gardner (1941) has reported adult emergence from 31st March to 4th April. Eggs are opaque and brown. They are 2.5-2.75 mm long with rounded ends. Grub is apodous with a translucent cream-coloured body and light brown head. Larvae feed actively for a period of 4-5 months. Thereafter, they stop feeding and remain quiescent after plugging the larval tunnel from inside. Pupation started from January as against the last week of March in the case of *O. lateapicalis*. But larval stage was observed even in March. Pupation took place in a pupal chamber constructed at the base of the larval tunnel. Fresh pupae were creamy yellow with well developed antennae and legs. In due course of development, wing pads developed. Adults emerged out through a circular exit hole during night. Adult is an yellow longicorn beetle. Antennae, eyes, distal two thirds of elytra and the last abdominal segment are jet black in colour. It has an average body length of 1.4 cm. Antenna measures 1.3 cm.

Nature of Damage

Female beetle girdles the bark of tender branches below 3-6 nodes from the apical bud and inserts a single egg vertically inside the bark. Portion of the twig above the girdled region slowly dries. This is the initial symptom of attack (See Fig.). Meanwhile, larva hatching out of the egg bores in to the branch from tip downwards. As it bores downwards, makes ventilation holes on the stem and ejects wood powder and fecal pellets through it. Wood powder that falls on the lower leaves help in detecting affected branches. As the attack advances, twig shows die back symptom. Larvae were found to bore down to a length of 1 to 2 m. As the tip of the attacked shoot withered away, the grub closed the hole with

Fig. 1.

fecal pellets. Adults feed on the leaves along the veins, making linear incisions. Infestation up to 10% of the branches was noticed in some fields near Chengannur.

Univoltine life cycle of the pest makes control rather easy. Collection and destruction of the adults and pruning of the affected branches harbouring larvae were found to give satisfactory control of the pest. Leaving mulberry uncared for and without pruning should be discouraged. Since such plants will host the insect throughout the year and enable it to complete the life cycle.

This is the first report of *O. artocarpi* on mulberry.

ACKNOWLEDGEMENT

The author is grateful to Dr. D. G. Booth, International Institute of Entomology, London for identifying the insect.

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ENTOMON 1995 VOL. 20 NO. 1 PP. 71 TO 73

[Brief Communication]

New Species of Spider of the Genus *Oxyopes* Latreille from India

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Received on March 31, 1993

Abstract: A new species of the spider, *Oxyopes ludhianaensis* sp. nov. is described and illustrated. Another species, *O. pandae* is recorded for the first time from northern India. Both the species were found predating on insect pests of oil seed crops.

Key words: New species, *Oxyopes*, Oxyopidae, India.

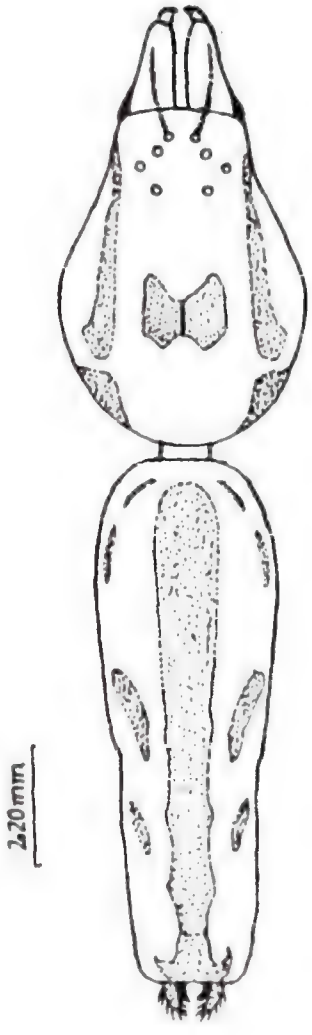
The spiders of the genus *Oxyopes* Latreille of the family Oxyopidae are little known members of Indian fauna. Pocock (1901) was the first to describe a few species but his descriptions were inadequate and without illustrations. Sheriff (1951) redescribed and figured Pocock's species of *Oxyopes* Latreille. Tikader (1965 and 1969) added four more new species to the existing list of *Oxyopes* of India.

While examining the spider collection made during the survey of spiders predaceous on insect pests of oil seed crops, we came across two species of *Oxyopes*, one of which is new and described here as *O. ludhianaensis* and the other is already known from India but is collected for the first time from northern India. The new species is named after the locality.

All the measurements given in the description of species are in mm. The abbreviations Am, AL, PM and PL stand for anterior median, anterior lateral, posterior median and posterior lateral eyes respectively and P. A. U. for the Punjab Agricultural University.

***Oxyopes ludhianaensis* sp. nov.** (Figs 1-5)

Female: Carapace: length 3.30, broadest width 2.60, with alternate irregular light and dark olive patches, thoracic region almost circular, thoracic fovea long and reddish brown. Eyes: Pearly white, encircled by black rims; anterior row strongly recurved, posterior row strongly procurved, apparently forming four rows of eyes of two each, anterior laterals and eyes of posterior row arranged in a manner to form a hexagon. Diameter of eyes: AM. =0.140, A. L. = 0.234, P. M. =0.234, P. L. = 0.234. Mutual distance between the eyes: AM-AM=0.280, A. L. -A. L. =0.480, A. M. -AL=0.100, P. M. -P. M. =0.480, P. L. -P. L. =0.960, P. M. -P. L. =0.400. Cypeus: width 0.240, yellow, marked with two dark streaks that extend up to anterior median eyes and chelicerae. Chelicerae: length=0.980, broadest width=0.582, pale yellow, anterior surface of each chelicera with a dark streak merging with the streak of clypeaus; promargin of chelicerae with two teeth, the second one being smaller than the first, retromargin with a single tooth, lateral condyl distinct. Labium: yellowish brown, longer than broad, extending up to more than half the length of maxillary lobes, anterior margin beset with a few setae. Maxillary lobes: cylindrical, yellow but with a brown patch and a few black setae anteriorly. Sternum: length 1.000, broadest width 1.130, pale-yellow, broader anteriorly and pointed posteriorly, sternal cones distinct and facing each coxa. Legs: pale-yellow, conspicuously spinose, spines standing out at a considerable angle,



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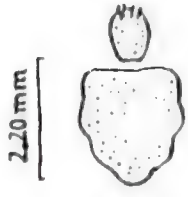

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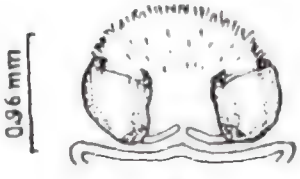

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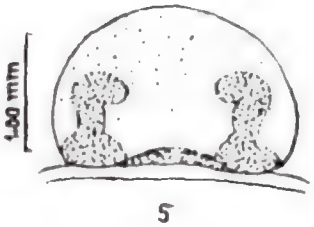

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Figs.1-4. *Oxyopes ludhianaensis sp.* nov. 1. Dorsal view-Female (legs omitted). 2. Inner view-chelicera. 3. Ventral view-labium and sternum. 4. Ventral view-epigynum. 5. Dorsal view of epigynum.

tarsal claws three, claw tufts absent. leg formula 1423.

Abdomen: Length 5.400, broadest width 1.800, dorsum with a medium reddish-brown band flanked with similarly coloured oblique patches, broad and rounded anteriorly and tapering posteriorly. Venter pale-yellow with a dark median band interrupted with yellowish spots and flanked by white mottling, anterior spinnerets slightly smaller than posterior ones; tubercle conical and long. Epigynum as in Fig. 4.

Male: Not known.

Holotype: One female: Para type: 500 in spirits.

Type of locality: PAU Campus, Ludhiana, Punjab, 3. V.1991. Coll. Neena Kumari Goel.

Distribution: Known from type-locality and also from Barewal and Habowal 5 KM west of Ludhiana, Punjab.

The types are housed in the Arachnological collections of the Department of Zoology, P.A.U., Ludhiana but will be deposited in the National collection of the Zoological Survey of India, Calcutta in due course of time.

Remarks: The present form resembles slightly *Oxyopes pandae* Tikader but differs considerably in colour pattern particularly in having irregular light and dark patches on cephalo thorax and in the absence of narrow black bands on the ventral side of each femur. The epigynum is also very different.

***Oxyopes pandae* Tikader**

Oxyopes pandae Tikader, 1969, *Oriental Ins:* 33.

Material examined: 6 females, 20. V. 1991, 4 males, 3. VIII. 1991, ex. leaves and flower heads of sun flower, P. A. U. Ludhiana, coll. Neena Kumari Geo 1.5 females ex. leaves of cotton plants, 15. V.1992, Barewal (Ludhiana), coll., G. L. Sadana; 7 females, ex. sun flower plants, 25. VI. 1992. Habowal (Ludhiana), coll., Gujarat Singh.

Acknowledgements

The authors are grateful to Dr. H. S. Toor, Professor and Head, Department of Zoology, Punjab Agricultural University, Ludhiana for providing the laboratory facilities and to Dr. A. S. Sohi, Professor of Entomology (Taxonomy), Punjab Agricultural University, Ludhiana for determining the insect pests.

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ENTOMON 1995 VOL. 20 NO. 1 PP. 75 TO 79

[Brief Communication]

New Species, New Records of Brevipalpid Mites and Their Hosts From Northern India

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Received on August 7, 1992

Abstract: A new species of brevipalpid mites namely *Brevipalpus jambhiri* sp. nov. has been described and illustrated. *Brevipalpus cucurbitae* Mohanasundaram has been recorded for the first time from northern India. Of the eleven species of brevipalpid mites recorded during the survey in the Punjab State, eight species namely *B. cucurbitae, B. deleoni* Pritchard and Baker, *B. tinsukiaensis* Sadana and Gupta, *B. rice* Chaudhri, *B. californicus* (Banks), *B. ovobatus* Donnadieu, *B. rugulosus* Chaudhri, Akbar and Rasool and *B. phaencis* (Geijskes) have been recorded on new host plants. These species are listed together with collection data.

Key words: New species, New host and mite records, Brevipalpid mites

INTRODUCTION

The brevipalpid mites of the family Tenuipalpidae are strictly phytophagous and hence of great importance because of the economic losses which they bring about by their infestation to crops, fruit trees, vegetables, medicinal, ornamental and other plants of economic importance. The feeding activity of these microscopic mites results in bronzing, silvering, stippling of leaves, scars and deformities in leaves and fruits and stunted growth of plants. In spite of their great economic importance very little efforts have been made to explore this mite fauna in the Punjab State. Whatever little knowledge has accumulated on these mite is due to the work of Gupta *et al.*, 1971; Sadana, 1985; Sadana and Chhabra, 1980a and b; Sadana and Gupta, 1982, 1983; Sadana and Sidhu, 1990; Sadana *et al.*, 1981, 1983 and 1985. With a view to know the brevipalpid mite fauna of the Punjab State, extensive surveys were made and a large number of mites were collected from various economic plants.

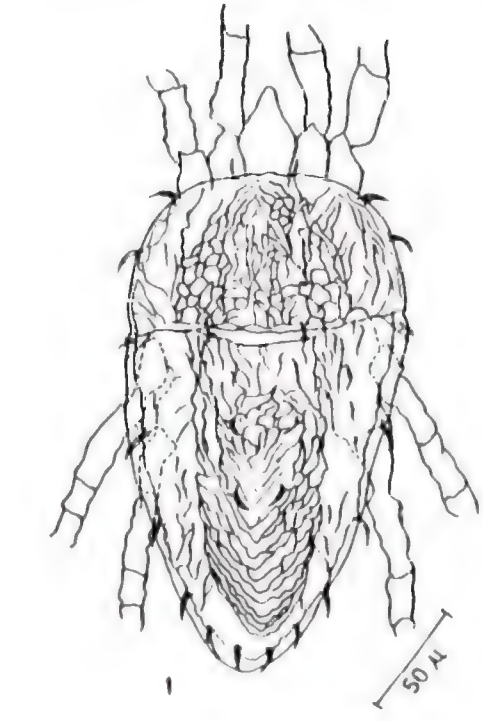
The survey work revealed the presence of eleven species of the genus *Brevipalpus* in the State. Of these, one is new species. *B. cucurbitae* Mohanasundaram has been recorded for the first time from northern India. Out of the other recorded species namely *B. assasmensia* Sadana and Gupta, *B. californicus* (Banks), *B. deleoni* Pritchard and Baker, *B. karachiensis* Chaudhri, Akbar and Rasool, *B. obovatus* Donnadieu, *B. phoenicis* (Geijskes), *B. rica* Chaudhri, *B. tinsukiaensis* Sadana and Gupta and *B. gauhatiensis* Sadana and Gupta, only those species are included here with collection data which have been collected on new host plants because the other species recorded during the survey have been reported during the survey have been reported hither-to-fore by different authors quoted above.

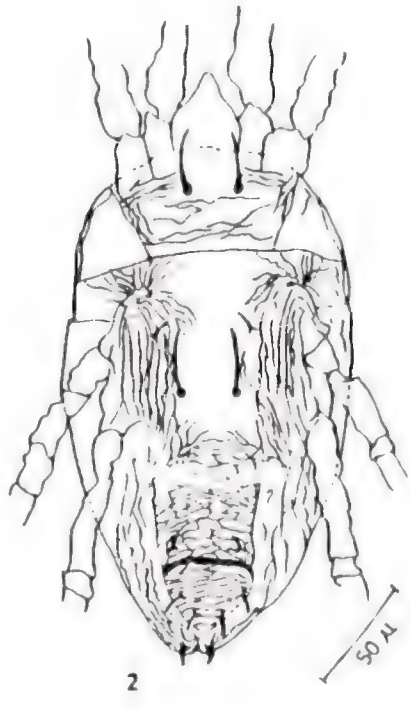
The holotype and paratypes and specimens of recorded mites are deposited in the acarological collections of the Department of Zoology, Punjab Agricultural University, Ludhiana.

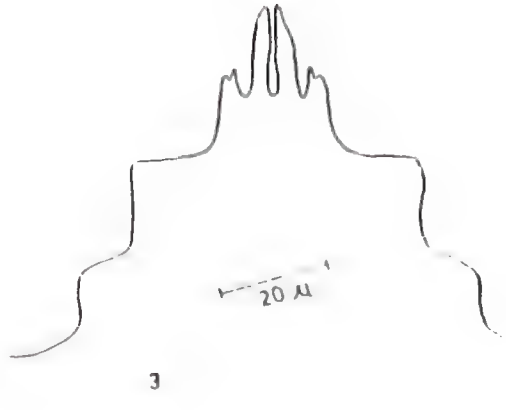
The measurements given with the description of new species are in microns except otherwise stated.

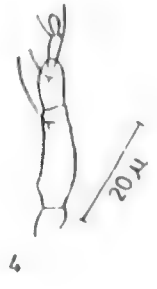
1. ***Brevipalpus jambhiri* sp. nov.** (Figs. 1-4)

Female: Body 203 long (without rostrum) and 133 wide. Palpus 4 segmented, terminal segment with one sensory rod and 2 setae. Hostrum reaching up to middle of femur-I. Rostral shield with one median and 4 lateral lobes on each side. Propodosoma with









Brevipalpus jambhiri sp. nov. 1. Dorsal view of female (Legs partially shown), 2. Ventral view of female (legs partially shown), 3. Rostral shield, 4. Palp.

reticulations mediolaterally fading away laterally, propodosomal setae 3 pairs, lanceolate, measuring 8,10 and 10, respectively. Eyes 2 pairs, one par on each side. Humeral setae one pair, 6 long. Hysterosoma with longitudinal wavy lines mediolaterally, turning oblique posteriorly and meeting caudally, faint broken striations and a few thin reticulations medially; broken striations laterally. Dorsocentral setae 3 pairs, simple, measuring 8,6 and 10 long, respectively. Dorsolateral setae 5 pairs, lanceolate, measuring 6, 10,10, 10 and 8 long, respectively.

Ventrally, propodosoma with a few transverse striations near the base, of coxae I and II; broken striations medially. Area anterior to coxae-III with striations arranged in a stellate type arrangement, longitudinal striations in front of coxae III and IV. Medioventral propodosomal setae one pair, measuring 18 long. Anterior and posterior medioventral metapodosomal setae one pair each, measuring 6, 26 long respectively. Posterior region of metapodosoma close to coxae-IV with striations. Ventral shield reticulated with elongated cells; with a pair of setae, each seta 6 long. Genital shield with transverse striations; beset with 2 pairs of setae, measuring 8 and 10 long, respectively, Anal shield setae one pair, each seta measuring 6 long. Opisthosoma with a few wavy and broken striations laterally.

Legs 4 pairs; segments wrinkled. Setae on legs I-IV: Coxae 2-2-1-1; trochanters 1-1-2-1; femora 4-4-2-1; genua 3-3-1-1; tibiae 5-5-3-3-. Setae on tarsi not clear. Tarsus-II with two sensory pegs. Dorsal setae on femora-I and II not longer than the width of segment.

Male: Not known.

Collection data: Holotype: 1 ♀, slide No.1, ex. jatti khatti, *Citrus jambhiri* 13.10.1988, Punjab Agricultural University (P.A.U) (Ludhiana). Coll. Balpreet Paratype: 2 ♀♀ slide No.105, ex *C. jambhiri* 2.1.1992 P. A. U. Coll. G. L. Sadana.

Remarks: The present form shows slight resemblance with *Brevipalpus phoenicis* (Geijskes) in the striation pattern of dorsum but differs from it in having rostral shield with a medium lobe and four lateral lobes on each side; a few faint reticulations medially on hysterosoma and absence of reticulations posterior to coxae-II and III, anterior to coxae-III, IV and ventral shield. In view of these differences, the present form is described as new and is named after its host plant.

2. ***Brevipalpus cucurbitae*** Mohanasundaram, 1982.

Material examined: 4♀♀ ex *Citrus aurantifolia*, Khanna 2, III. 1992. coll. G. L. Sadana.

This species has been recorded for the first time from northern India on a new host given in collection data. Earlier it has been recorded from Tamil Nadu on Squash (Mohanasundaram, 1982).

3. ***Brevipalpus deleoni*** Pritchard and Baker, 1958.

Material examined: 3♀♀ *Citrus jambhiri*, Punjab Agricultural University (P.A.U), Ludhiana, 16.10.1988, coll. Balpreet; 1 ♀ Village Thala (Jalandhar), 29, XII. 1988, coll. A. S. Grewal. 1♀ ex *Citrus aurantifollia*, village Mansuran (Ludhiana), 14. XII. 1988, coll. Prabhjot; 3 ♀♀ ex *Ficus carica* Kharar, 12. XII. 1992, coll. G. L. Sadana.

4. ***Brevipalpus tinsukiaensis*** Sadana and Gupta, 1983.

Material examined: 2♀♀ each ex *Citrus medica* var. *Acida* and *C. jambhiri* Bathinda, 18. IV.1992, coll. Gurjant Singh; 2♀♀ each ex *Melia azadirachta, Syzygium cumini* and *Vitis vinifera*, Khanna, 15. III. 1988, coll. G. L. Sadana.

5. ***Brevipalpus rica*** Chaudhri, 1972.

Material examined: 3♀♀ ex *Tecoma stans*. Ludhiana (P. A. U.), 23. VI. 1988. Coll. G. L. Sadana.

6. ***Brevipalpus californicus*** (Banks, 1904).

Material examined: 4♀♀ ex *Populus nigra italica*, Jalandhar, 2. VI. 1988, coll. G. L.

Sadana.

7. ***Brevipalpus obovatus*** Donnodieu, 1875

Material examined: 2 ♀♀ ex *Morus alba*, Samrala (Ludhiana), 10. IV.1988; 3♀♀ ex *Vitis vinifera*, Patiala 12. V. 1988; 2 ♀♀ ex *Citrus Limon*, Ludhiana (P. A. U.) 7. III.1987. Coll. G. L Sadana.

8. ***Brevipalpus rugulosus*** Chaudhri, Akbar and Rasool, 1974.

Material examined: 3♀♀ ex *Morus alba*, 4♀♀ ex *Musa Paradisiaca*, Pathankkot, 4. V.1987; 2♀♀ ex *Citrus sinensis* var. *Musambi*, 4♀♀ ex *Prunus domestica*, Ludhiana (P. A. U.), 26. V.1987; 2♀♀ ex *Carthemus roseus*, Jalandhar, 5. V. 1987; 5♀♀ ex *citrus medica* var. *acida*, Hoshiarpur, 6. V.1987; 3♀♀ ex *Thevetia pervuviana* and 4♀♀ ex *Psidium gauajava*, Samrala (Ludhiana), 10. II.1988. coll. G. L. Sadana.

9. ***Brevipalpus phoenicis*** (Geijskes, 1939)

Material examined: 5♀♀ ex *Citrus sinensis* var. *Musambi*, 3♀♀ ex *C. reticulata* var. *kinnow*, 4♀♀ ex *C. medica* var. *acida*, Ludhiana, 12. III. 1987. coll. Vijay Kumar; 2♀♀ ex *Carthamus roseus*, Jagraon, 10. IV.1987. coll. Meena; 3♀♀ ex *Melia azadirachta*, 4♀♀ ex *Populus nigra italica*; 3♀♀ ex *Grewia microcus*, Ludhiana, 20. IV.1987. coll. Vijay Kumar; 2♀♀ ex *Bougainvillea glabra*, Ropar, 26. IV.1987. Coll. Vijay Kumar.

ACKNOWLEDGEMENTS

The authors are thankful to Dr. H. S. Toor, Professor and Head, Department of Zoology, Punjab Agricultural University, Ludhiana for encouragement and laboratory facilities and to the Indian Council of Agricultural Research, New Delhi for funds. They also express their gratefulness to Dr. (Mrs) M. Dhillon, Associate Professor of Botany, Punjab Agricultural University, Ludhiana for extending help in the identification of Plant material and to Messrs. A. S. Grewal, Gujarat Singh and Vijay Kumar and Miss Prabhjot and Meena for assistance in collection work.

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Index to Authors

Statement of ownership and other particulars about ENTOMON

(Form IV, Rule 8 of Registration of Newspapers (Central) Rules 1956)

1. Place of publication:	Trivandrum
2. Periodicity of publication:	Quarterly
3. Printer's name, nationality and address:	D. Muraleedharan, Indian Department of Zoology University of Kerala, Kariavattom Trivandrum 695581
4. Publisher's name, nationality and address:	-do-
5. Editor's name, nationality and address:	-do-
6. Name and address of the individual who owns the newspaper:	Association for Advancement of Entomology Department of Zoology, University of Kerala Kariavattom, Trivandrum 695581

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Sd\-
D. Muraleedharan
Publisher, ENTOMON

Trivandrum,
31 March 1995

Reg. No. R. N. 29386/76

Published by D. Muraleedharan and Printed at Swift Offset Press, Trivandrum 695014 for the Association for Advancement of Entomology